TOCKLAI EXPERIMENTAL STATION

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ANNUAL SCIENTIFIC REPORT

1974-75

TEA RESEARCH ASSOCIATION, CALCUTTA

OUR COVER
Land Planning and Contour Planting of Tea.

TEA RESEARCH ASSOCIATION

Annual Scientific Report

(1st April 1974 to 31st March 1975)

Published by
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Director's Report

(1st April 1974 to 31st March 1975)

ORGANISATION

On the 31st March 1975, the Senior Staff consisted of :—

Directorate :

Director
N. K. Jain, M.Sc. Ag. (B.H.U.), Ph.D. (Illinois)

Administrative & Finance Controller
J. Tessier-Yandell upto 30. 9. 74.

Administrative Officer
K. S. Gill

Asstt. Administrative Officer
B. S. Kotoky, B.A., LL.B.

Accounts :

Accounts Officer
S. Mazumdar, B.Com. (Cal.) A.C.A.

Maintenance :

Station Engineer
G. B. Singh, A.M.I.S.E.

Medical :

Medical Officer
Dr. (Major) S. W. Rohman, M.B.B.S.

Library & Publication Department :

In-Charge
J. N. Sharma, M.A. (Gau.)

Soils & Meteorology Department :

Soil Scientist
S. K. Dey, B.Sc. (Cal.), Assoc. I.A.R.I.

Senior Scientific Assistants
N. G. Bhattacharyya, B.Sc. (Cal.)
A. K. Sengupta, B.Sc. (Cal.)

Botany Department :

Plant Physiologist
W. Hadfield, B.Sc. , Hons. upto 17.10.74

Plant Breeder
H. P. Bezbaruah, M.Sc., Ph.D. (Gau.)

Senior Scientific Assistant
B. N. Gogoi, B.Sc. (Gau.)

Agriculture Department :

Agronomist
F. Rahman, M.Sc. Ag. (Bihar), Ph.D. (I.A.R.I.)

Second Agronomist
B. C. Phukan, B.Sc. Ag. (Gau.), A.I.F.C.

Manager, Borbhetta Experimental Estate
H. N. Sharma, B.Sc. (Cal.)

Entomology Department :

Entomologist
B. Banerjee, M.Sc. (Cal.) M.S. (South Illinois), Ph.D. (London), F.A.Z., F.R.E.S. (London).

Senior Scientific Assistants
N. S. Sengupta, B.Sc. Ag. (Cal.)
M. C. Katoni

Mycology Department :

Mycologist
G. Satyanarayana, B.Sc. (Hons.) (Andhra), Ph.D. (Madras) F.B.S., F.I.P.S.

Biochemistry Department :

K. L. Bajaj, M.Sc. (K.U.), Ph.D. (Punjab Agricultural University)

Senior Scientific Assistant
S. Chakrabarty, M.Sc., Ph.D. (Cal.)

Tea Tasting Department :
Tea Taster
R. P. Basu

Second Tea Taster : *West Bengal*
S. Sen, B.Sc. (Cal.)

Third Tea Taster
A. K. Das, B.A. (Gau.)

Engineering Research & Development Department :
Senior Research Engineer
D. N. Barbora, B.Sc. Mining (B.H.U.) M.Sc. Eng. (London), D.I.C., M.I. Ag.E.

Second Research Engineer
T. C. Baruah, B.Sc. (Hons.), (Gau.) B.Sc. Mech. Eng. (B.H.U.), M.Sc. Mech. Eng. (Manchester)

Statistics Department :
Statistician
A. K. Biswas, M.Sc. (Gau.)

Agricultural Economics Department :
Agricultural Economist
R. C. Awasthi, M.Com., LL.B., Ph.D. (Agra)

Advisory Department :
Senior Advisory Officer : Assam
P. C. Sharma, M.Sc. (B.H.U.), Ph.D. (London) F.L.S.

Advisory Officer : South Bank: *Upper Assam*
T. K. Ghosh, B.Sc. (Patna), Ph.D. (Cornell) Assoc. I.A.R.I.

Advisory Officer : *Lower Assam*
B. Borthakur, M.Sc. Ag. (Gau.)

Asstt. Advisory Officer
S. C. Dey

Advisory Officer : *North Bank*
H. Mitra, B.Sc. (Cal.)

Asstt. Advisory Officer : *North Bank*
M. Farook, B.Sc. Ag. (T.N.A.U.

Advisory Officer : *Cachar*
J. Chakravartee, M.Sc. Ag. (Gau.)

Advisory Officer : *West Bengal*
S. Basu, B.Sc. Ag. (Hons.), (Delhi) Assoc. I.A.R.I.

Advisory Officer : *Dooars & Terai*
B. C. Barbora, M.Sc. Ag. (I.A.R.I.)

Asstt. Advisory Officer: *Dooars & Terai*
K. N. Dutta

Advisory Officer : *Darjeeling*
S. K. Sarkar, B.Sc., (Cal.), B.Sc. Ag. (B.H.U.)

SENIOR STAFF MATTERS

Appointment

The following appointments and promotions were made :

Mr. B. S. Kotoky — promoted as Asstt. Administrative Officer, with effect from 1.9.74.

Mr. K. N. Dutta - promoted as Asstt. Advisory Officer, with effect from 1.9.74.

Mr. S. C. Dey - promoted as Asstt. Advisory Officer, with effect from 1.9.74.

Mr. M. Farook — appointed as Asstt. Advisory Officer, with effect from 16.10.74.

Dr. K. L. Bajaj — appointed as Biochemist with effect from 9.11.74.

Dr. R. C. Awasthi—appointed as Agricultural Economist, with effect from 6.12.74.

Retirement

Mr. J. Tessier-Yandell, Administrative & Finance Controller, retired on 30th September, 1974.

Mr. W. Hadfield, Plant Physiologist, retired on 17th October, 1974.

TRAINEES

Four Research Students worked at Tocklai Experimental Station during the year under C.S.I.R. Jr. Research Fellowship, two in Botany Department and one each with the Soil and Engineering Department.

In addition, two trainees from Iran have completed one month's training each and one each from Nepal and Mauritius have completed three months training.

LECTURE COURSES

The following lecture courses were held during the year :-

Surveying and Drainage Course

(a) For Government Approved and Estate Surveyors from 16th to 18th January, 1975.

(b) For Planters
1st Course from 6th to 10th January, 1975.
2nd Course from 20th to 24th January, 1975.
3rd Course from 27th to 31st January, 1975.

VISITS

The Director attended the meetings of Research Liaison Committee and Development Committees of Tea Board, Council of Management, Agricultural and Engineering Sub-Committees of T.R.A., C.S.I.R. Directors Conference, meetings of I.C.A.R. Society I.S.I. Committees, Biological Research Committee of C. S. I. R., I. C. A. R./C. S. I. R. Joint Panel and Various A.S.C. meetings including the Joint Area Scientific Committee in North Bank. He also attended seminar of Fertilizer Corporation of India with the Soil Scientist. He delivered lecture on Recent Advances in Agronomy at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur.

Agronomist attended the meeting of ISI and Study Committee of I.C.A.R.

Senior Research Engineer visited Bangalore and Madras. Other specialists attended various A.S.C. meeting, T.R.A., A.G.M. was attended by Agronomist and Administrative & Finance Controller, on invitation. A.G.M. of UPASI was attended by S. Basu.

VISITORS

The following distinguished persons visited Tocklai during the year under review :-

Sri Tarun Gogoi, M.P.; Mr. P. V. Parameswaram, M/s J. F. & Co., Munnar, Kerala; Mr. J. C. Templer, Tea Research Institute of East Africa; Mr. A. Basu, Hoechst Pharmaceutical Ltd., Calcutta; Dr. A. S. Induikar, Technical Executive Hoechst Pharmaceutical Ltd., Bombay; Dr. B. S. Mankodi, Swastik Household and Industrial Products Ltd., Bombay; Mr. S. S. Bhatia, Selser Marketing (P) Ltd., Calcutta; Mr. P. K. Gokhale, C.S.I.R. New Delhi; Mr. B. N. Patel, Agricultural Research Institute, Tanzania, East Africa; Mr. Sumat Prashad, Vice-Chairman, T.R.A. Calcutta; Mr. N. A. Kuthial, Coonoor Nilgiris; Mr. A. Schwarz, Malawi; Prof. M. M. Chakraborty, Dr. C. R. Lahiri and Dr. T. K. Raha, Calcutta University; Mr. Keiko Hirasawa, Tokyo, Japan; Mr. A. F. Macdonald, Member, London Scientific Committee TRA; Mr. F. R. Wilson, Duncan Macneill & Co., London; Mr. M. Lamond, London Scientific Committee; Mr. S. K. Suri, N.P.L., New Delhi; Mr. A. K. Mehra, Planter from South India; Dr. R. H. Fulton Rohm & Haas Co.; Philadelphia; Mr. R. K. Datta, Indofil Chemicals Ltd., Calcutta; Mr. L. Ramakrishnan, Indofil Chemicals Ltd., Calcutta; Mr. J. H. Fuchter, Uniroyal Chemical, Singapore; Mr. G. L. Phatak, Bharat Pulversing Mills, Madras; Mr. B. K. Sarronwala, Duncan Bros. & Co. Ltd., Calcutta; Mr. R .C. Punshi, Duncan

Bros. & Co. Ltd., Calcutta; Mr. P. K. Ghosh, IBM World Trade Corporation, Calcutta; Mr. John Trinick, George Williamson & Co., London; Mr. P. Antony Reddi, Andhra Pradesh; Mr. V. B. Raju, New Delhi; Mr. G. R. Patel, M.P., New Delhi; Mr. Y. S. Mahajan, M. P.; Prof. Shibbanlal Saksena, M.P.; Mr. Ram Kishore, Committee Officer, Lok Sabha, New Delhi; Prof. B. N. Shastri, M.P., New Delhi; Dr. K. K. Mitra, Tea Board, Calcutta; Dr. L. S. Negi, Vice-Chancellor, A.A.U., Jorhat; Dr. C. Thakur, Vice-Chancellor, J.N.K.V.V., Jabalpur; Mr. B. Sivaraman, Planning Commissioner; Mr. H. Ferguson, James Finlay & Co. Ltd., Glasgow; Dr. A. K. Saha, Head of the Deptt. of Horticulture, B.C.K.V.V., West Bengal; Mr. S. C. Sharma, Indian Potash Ltd., Calcutta; Dr. Dharmapal Singh, Director U.P. Inst. of Agricultural Sciences, Kanpur; Dr. V. L. Chopra, Head, Division of Genetics, IARI; Mr. M. W. Griffiths, Jardine Henderson Ltd.; Mr. G. A. Whitaker, Empire & Singlo Tea Co. Ltd., Dr. T. Sankaran, Commonwealth Institute of Biological Control Indian Station, Bangalore; Dr. N. K. Sogani, Scientist, R.R.L. Hyderabad; Mr. S. M. Ispahani, Philips Duphar, Amsterdam; Col. N. K. Sen, Senior Director, Survey of India, Hyderabad; Mr. F. J. B. de Fonseka, Carson Curuberbatch & Co. Ltd., Sri Lanka; Dr. S. C. Dutta, Asstt. Director General (ASE) I.C.A.R., New Delhi; Mr. R. K. Renford, 3 Chessington Avenue Finchley, London; Dr. S. L. Katyal, Asstt. Director General (Hort.), I.C.A.R. New Delhi; Dr. K. S. Narang, Vice-Chancellor, Patiala University; Mr. J. N. Das, Vice-Chancellor, Dibrugarh University; Mr. H. R. Salama, Import & Export Co., Cairo, Egypt; Brig. S. K. Das, Inspector ASC, Army HQ, New Delhi; Mr. D. R. Kohli, Deputy Chairman, State Planning Board, Shillong; Prof. Dr. W. Gottrchalk, University of Bonn, Germany; Mr. R. N. Deogun, James Finlay & Co. Ltd., Calcutta; Mr. Baldev Singh, Chief Technology Utilisation, C.S.I.R., New Delhi : A 12 member French Tea Delegation including Mr. J. Runner, President Committee Francais du The; Mr. Raymond Scala; President Du Syndicat National Des Importateurs De The; Mr. Jacques Liabeuf, Ingenieur Agronome I.N.A. Adjoint Au Directeur General De L.I.F.C.C; Justice Baharul Islam, Gauhati High Court; Dr. O. P. Gautam, World Bank Washington DC; Dr. M. K. Molani ADG (IDA) ICAR, New Delhi; Mr. K. Lenz, C/o Consulate General of the Federal Republic of Germany, Calcutta; Mr. Mir Mozhar Ali, Bangladesh Tea Research Instt., Sylhet; Mr. A. F. M. Badrul Alam, Bangaladesh Tea Research Instt., Sylhet; Mr. H. A. Jmpari, Iran-Lahidjan, Tea Organisation; Mr. M. A. Nabaui, Tea Organisation, Iran; Dr. B. Ramamoorthy, Emeritus Scientist I.A.R.I., New Delhi; Public Accounts Committee led by Shri Jyotirmoy Basu, Chairman; Mr. H.N.Chatterjee, Port Engineering Works, Howrah.

Dr. Tadakzu Takeo, Biochemist, National Research Institute of Tea, Japan spent 6 weeks at Tocklai working as a Guest Scientist in Biochemistry Department. His visit was sponsored by the Ministry of Agriculture Govt. of Japan.

Advisory Department

General

The Advisory Officers continued routine touring, and organized Area Scientific Committee Meetings, Seminars and Lecture Courses in their respective areas. The Senior Staff was strengthened by the addition of three Assistant Advisory Officers and this will help meeting the increasing demand on advisory services owing to increased membership. After completion of their necessary training at Tocklai, Mr. K. N. Dutta was posted in the Dooars, Mr. M. Md. Farook in the North Bank and Mr. S. C. Dey at Tocklai during January/February 1975. There was no other change in the Senior Staff.

The Department organised a Joint Area Scientific Committee Meeting in the North Bank in March 1975, which was attended by a large number of planters from Assam and West Bengal. Scientists from South India, Bangladesh and Japan also participated in this meeting.

Visits

The demand on advisory services continued to be heavy and advisory officers tried their best to pay at least two visits in a year to each member estate. Special visits were paid to estates whenever required. The Advisory Officers also visited regularly experimental sites in the tea estates to ensure smooth running of the experiments. Besides, a number of estates were visited in connection with the Seminars. Table 1 gives the details of the advisory visits in each district :

There was an overall increase in the number of visits to member estates during the year under review as compared to the previous year. A satisfactory trend was that more member estates utilised advisory services during 1974.

Table 1. Details of advisory visits in the member estates during 1973 & 1974 districtwise

Districts	No. of visits during		No. of member estates visited during		Total number of Member estates	
	1973	1974	1973	1974	1973	1974
South Bank	282	287	202	226	265	283
North Bank	119	157	59	77	88	90
Cachar	119	112	42	52	53	56
Dooars	157	196	76	81	89	95
Terai	20	28	11	18	20	22
Darjeeling (including Sikkim)	101	125	46	53	49	55
Total :	789	905	439	507	564	601

Crop & Weather

(a) **Assam :** The first part of the year 1974, remained comparatively wet and all the areas except Moran, Naharkatia and Tingri harvested more leaf compared to previous year. The second quarter of the year under review was relatively dry and the temperature remained high, particularly during end July and August 1974. During this period most of the estates in the South Bank started losing crop heavily. However, from the beginning of the third quarter weather became favourable and continued to remain so, which helped most of the estates to recover the loss sustained earlier during the second quarter due to inclement weather. The back-end season was quite favourable as the mercury level was comparatively high during this time of the year and useful rain was also received in most of the areas. As a result, substantial gain in back-end crop added to the outturn of made tea except in Doom Dooma sub-area. The early part of 1975, remained droughty all over except some parts in Upper Assam. Most of the estates, therefore, remained behind in crop except some pockets of Moran, Naharkatia and Tingri. The magnitude of crop loss during the early part of 1975 varied from high to moderate particularly in the estates of lower and central Assam.

In Cachar rainfall was well distributed during the beginning of 1974 and the estates could make exceptionally good crop during the year. Rainfall over the period November 1974 to March 1975 was far below normal and this resulted in drought condition which caused a severe set back to the Cachar gardens.

In general, crop position in North Bank was also very good during the year. Some gardens suffered during the droughty months at the end of 1974 and early 1975.

(*b*) **West Bengal:** As a result of well distributed rainfall during the cold weather and spring, 1974 proved to be an exceptionally good year for the Dooars and Terai. At the end of the season, most estates made a record crop.

In Darjeeling the early crop was also very good but there was some shortfall during the rains because of adverse climatic conditions. However, the weather improved thereafter, and a large number of estates made up the loss.

Unfortunately, the 1975 season started ominously with an unprecedented drought, and a large percentage of early crop was lost. As the drought in West Bengal is a rule rather than an exception, a time has now come when the question of irrigation should be given due consideration by all concerned.

Land Planning & Drainage

(*a*) **Assam :** Within the limited resources available and the conditions prevailing, increasing trend of topographical planning and contour drainage is being observed both in the North & South Bank. Some estates preferred straight line planting in lieu of master row system although the drains were laid out on the contour.

In Cachar, level contour drains on teela slopes were the standard practice. In the recent years graded contour drains with shallow outlets running down the natural depressions have been suggested on trial basis. The suitability of such graded contour drains with shallow outlets under different soil conditions is yet to be thoroughly studied.

(*b*) **West Bengal:** A number of estates carried out level survey of their entire area in order to improve the existing drainage and conservation system, and some also started uprooting and replanting on a catchment basis. Contour drains were being provided in new plantations by many estates but the planting itself was seldom done on contour, with a few notable exceptions.

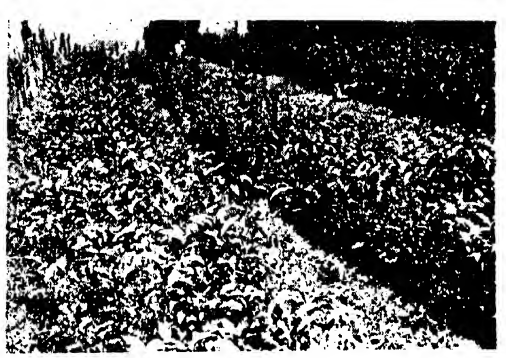
Undersized culverts, bridges and outlets continued to be the common factors which hampered the drainage system of many estates and advice was frequently given as to how to overcome these factors. In order to stop waterlogging due to seepage, permeability test of soil was also suggested on several occasions.

In Darjeeling, the situation in respect to land planning remained unchanged.

Tea Husbandry

Pruning Cycle

(*a*) **Assam :** Most of the estates followed three-year pruning cycle (LP-DS-MS). However, some estates replaced medium skiff by lighter forms of skiff in the third year. Estates which adopted longer pruning cycle with a substantial area under unpruned or level-off-skiff made good profit because of higher crop and a good market that prevailed last year.



One year old nursery at 5000′ elevation in a Darj eling T. E.

Some estates in Cachar introduced a four-year pruning cycle (Pr-UP-DS-UP) whereas some others have gone in for even higher percentage of unprune i.e. above 50%.

(*b*) **West Bengal :** In Dooars & Terai, by and large, four year pruning cycle with 50% unprune or level-off-skiff was most common At the suggestion of the advisory officers many estates avoided unprune or level-off-skiff in drought prone areas, and adopted three-year cycle (P-DS-DS) with advantage.

The standard of pruning was not satisfactory in many estates, the common fault being pruning continually at the same height. This resulted formation of a knotty pruning table which could only be corrected by medium pruning. Estates were urged by the advisory officers to leave at least 3 cm of new wood while pruning at the end of the pruning cycle.

It was a common practice to leave "breathers", "kickers" or "lungs" on bushes which were medium pruned or pruned very low for rejuvenation. At the suggestions of the advisory officers, many estates left "breathers" on young tea bushes also when they were pruned following two or three years of 'step-up' plucking. "Breathers", the estates claimed, greatly minimised sunscorch damage to the frames, and also induced better recovery from pruning.

In Darjeeling, it was observed that more and more estates were introducing deep skiffing in their longer pruning cycles to solve the problem of plucking the leaf in the heavy flushing month of April and the second flush period. The quality of tea made from deep skiffed areas was also reported to be upto the mark.

Plucking

(*a*) **Assam :** The member estates followed the tipping allowances normally recommended by us. However, with the enrolment of new members, it was observed that the tipping allowances followed by them after various types of pruning/skiffing needed drastic corrections.

As mentioned earlier, the impact of our advice on plucking had paid dividends to estates who followed it. Constant advice to pluck hard and black continued in areas where teas were left either unpruned, light/level-off or medium skiffed. It was emphasised that this type of plucking was particularly necessary where production of quality tea was of prime importance.

Recovery from Rejuvenation in a South Bank Estate

Step-up plucking, wherever followed, in suitable sections gave good results in the following year when the bushes were left unpruned. During the advisory visits to estates, it was observed that in some areas step-up plucking was being tried without forward planning about pruning/skiffing in the year to follow. This point was cleared by the Advisory Officers that no useful purpose would serve to practise step-up plucking in areas where the bushes were to be pruned in the following year.

Nevertheless, there has been some criticism of step-up plucking in mature tea from some quarters. The reason was that although the time of stepping up suited well with the labour availability but it became difficult to maintain an even plucking table after the stepping up, which was extremely necessary for obtaining the full benefit from that method.

In Cachar, step-up plucking was not advocated as a general practice, either in light pruned, medium pruned or unpruned teas as there was a possibility of the formation of comparatively thinner primaries.

(*b*) **West Bengal :** In Dooars & Terai, many estates tried step-up plucking in pruned, deep skiffed and unpruned teas where the tea would remain unpruned in the following year. This system, it was

reported, worked well, particularly in vigorously growing youngish mature tea.

The standard of plucking was generally not very satisfactory. The common faults were (i) too rapid rise in plucking table and (ii) sides of the bushes plucked below the general level of tipping. In a few cases, plucking was considered too hard, there being hardly any rise in the plucking table at the end of the season, and the bushes had a sickly appearance.

In Darjeeling, more and more estates realised that plucking round should be adjusted to the rate of growth because a uniform standard of leaf could then be maintained. Many estates who followed this system found that there was a significant reduction in stalk in the made teas, especially during the rains.

Rejuvenation

(*a*) **Assam :** Rejuvenation pruning has been in progress in Assam Valley for the last few years as a supplement to uprooting and replanting. Where it was done properly i.e. after resting, manuring etc., the recovery was satisfactory.

In Cachar, rejuvenation pruning was done in a few estates with good results.

(*b*) **West Bengal :** In Dooars & Terai, many estates carried out rejuvenation pruning during the year. The recovery from pruning had generally been found to be quite satisfactory. Encouraged by the good recovery from such a pruning, many estates were considering a heavy medium pruning in order to establish a low and clean bush frame free from diseases and knots. Such a pruning, of course, had to be supplemented with intensive infilling.

In Darjeeling, heavy pruning for rejuvenation of old tea was very common but little, if any, infilling was done.

Young Tea

(*a*) **Assam :** In Assam valley, a deviation from the low tipping and step-up plucking of young tea continuously for three years, introduced in the year before last, appeared to have some merits from the point of bush development. However, the time to use the knife after first centering/lung pruning is yet to be finalised. It would be of interest to mention here that the practice of pegging the young tea during the first year is on the increase. In upper Assam where the growth rate of young tea is comparatively faster, this method of bringing up young tea is gaining ground.

(*b*) **West Bengal :** In Dooars & Terai, pegging combined with step-up plucking was tried out by many estates to get a good ground cover as quickly as possible. Pegging, no doubt, induced an early spread but it was found to be quite expensive by many estates. Furthermore, where irrigation facilities were not available, pegged bushes suffered severely during the drought. Step-up plucking and pegging was discouraged on estates where the plants were not vigorous and weed control was unsatisfactory.

In some new plantations, the space between the rows was reduced from 120 cm to 105 -110 cm. Bush population varied between 12,000–20,000/ha.

In Darjeeling a very small area was replanted during the year. Except in a few estates, the management of young tea was generally unsatisfactory. The estates were reminded by the advisory officer that for better growth, the young tea must be kept free from weeds, pests and diseases.

Planting

(*a*) **Infilling :** In addition to infilling of young tea and block infilling of mature tea in some estates in the Assam valley, more emphasis had been given to infill the medium pruned and rejuvenated sections. The planting materials used were TV1, TV9, TV18 & Stock 203. Increasing interest in infilling of mature tea was also observed in Cachar.

Infilling was quite common in the plains of West Bengal, especially in the Dooars. The advisory officers put a lot of emphasis on infilling of medium pruned and rejuvenated sections. The materials commonly used for infilling were TV9, TV18, Stock 203 & Dangri Manipuri.

In Darjeeling, very little progress was made towards infilling, although its importance was repeatedly pointed out by the advisory officer.

(*b*) **Uprooting & Replanting :** In Assam Valley, uprooting and replanting has been going on side by side with extension planting. However, with the promulgation of the Land Ceiling Act by the Government of Assam, estates are laying more emphasis on extension rather than uprooting and replanting.

Rehabilitation after uprooting has been accepted widely but the period of rehabilitation yet remained debatable, particularly in the estates of Upper Assam. Guatemala and *Mimosa invisa* continued to be recommended as rehabilitation crops. Economic considerations, however, made Citronella preferable to others as a rehabilitation crop in some estates.

Rejuvenation pruning in a Cachar Estate

In Cachar estates where land for further extension is extremely limited, stress has been given to increase the rate of replanting than what is being practised at present.

In West Bengal, economically better-off estates continued uprooting and replanting more or less at the same rate as before. Others were hesitant to undertake uprooting work for fear of immediate loss in crop. This was very much true for Darjeeling where virtually no uprooting was done.

Propagation

(*a*) **Vegetative Propagation :** In Assam valley, clones like TV 11, TV 14, TV 17, TV 18, TV 19 & TV 20 are now being tried. TV 18 is gradually taking over from TV 9 mainly for the purpose of infilling. TV 1 has been used widely. In addition to these clones, other company clones such as P-126/A, Teen-Ali 17, S3A/3, CP-1, N-436 etc. are being planted out. Keyhung Clones and some other clones selected by various companies are also being gradually accepted. Tocklai released clones, known to have drought resistance capacity, have been advocated for Cachar.

In Dooars & Terai, a significant improvement had been made in the technique of vegetative propagation i.e. raised beds under north light overhead shade had given very satisfactory results, and propagation in sunken beds is steadily on the decline. Polythene sleeves were expensive and, therefore, many estates were forced to raise plants in beds. It was reported that the estates which planted cuttings first in rooting beds and then transferred them to sleeves, obtained better success at a lesser cost than planting directly into sleeves.

The popular clones were TV 1, TV 9 & TV 18, though it was becoming apparent that estates were not all that keen on TV 9. Drought resistant clones such as TV 12, TV 14, TV 16 & TV 17 were also in demand.

In Darjeeling, the leading estates increased their activities in vegetative propagation and made commendable efforts to establish clones which were suitable for Darjeeling. The clones released by Tocklai were also made available to estates who were not members of the Tea Research Association, but even then, the interest shown by them was rather poor.

Contour planted tea in a Darjeeling Tea Estate

It was emphasised by the advisory officers that every estates must make an effort to try all the seven clones which received interim certificate of approval from the Tea Research Association. Unfortunately, the response to this advice was not encouraging.

(*b*) **Seeds :** In the Assam valley clones were used for large scale planting either in extension or uprooted areas although some of the smaller estates are still using commonly available seeds. In Cachar, Stock 203 seeds were used in many estates both for infilling and new planting.

In Dooars & Terai, Stock 203 was in great demand, so was Dangri Manipuri—a hardy jat. Planters were no longer keen on using light leaf Assam jats which, in general, proved to be unsuitable for the Dooars and the Terai. A few estates had established biclonal stock 449 seed bari in the Dooars. It appeared that this stock would be quite suitable for West Bengal.

In Darjeeling, there was a great demand for stock 378 (Nanda Devi), but only 42 units could be supplied during 1974. It is, however, expected that the supply of seed would go up in the near future.

Fertilizers

(*a*) **Nitrogenous Manures :** There were some estates in Assam who applied nitrogenous manures at a much higher rate than recommended by Tocklai i.e. more than 90-135 kg N/ha. In the Dooars and Terai, the rate of nitrogen application varied from 80 135 kg/ha. In Darjeeling, estates were advised not to increase the rate of nitrogen application, unless they were confident to harvest extra crop due to higher application.

Some estates in Assam valley, Cachar and Dooars were continuing with split application of nitrogen in mature tea though we did not observe any beneficial effect of split application in our experiments.

(*b*) **Potash Manuring :** Potash manuring continued in Assam on the basis of soil analysis. In odd places, however, no response from continued potash application either in respect to crop or soil potash build up was observed. In Cachar, some estates did not follow our recommendation on potash manuring.

In Dooars & Terai, the progressive estates followed our recommendations, i.e., 40 kg K_2O/ha every third year. High rates of potash application were often advocated in sections where potash deficiency symptoms were discernible.

(*c*) **Foliar Application of Urea & Zinc :** In the Assam valley it was pointed out that the foliar application of urea on mature tea could be beneficial when the bushes could not take up this nutrient through the roots i.e. during the dry period in early part of the year or towards the end of the season during September/October where bushes might have suffered from waterlogging. In the Dooars & Terai, foliar application of urea during the early and back-end season was very popular. Even in Darjeeling, foliar application of urea was made by several estates during July to February, thus avoiding the first and second flush period.

Zinc sulphate had been sprayed widely in Assam Valley and the results were variable. In the Dooars and Terai, foliar application of zinc was tried by many estates on unpruned sections. The effect of foliar application of zinc on quality of made tea was under investigation both in Darjeeling and in the plains. The estates in Darjeeling were advised not to apply zinc during quality period.

(*d*) **Manuring of Young Tea :** Manuring of young tea was rather liberal in many estates in Assam. It appeared that estates were in a hurry to cash the return from the young teas, particularly where bushes are pegged and combined with low tipping and step-up method.

Weed Control

Due to shortage of herbicides like Gramoxone, Simazine etc., the programme of chemical weed control was affected adversely in some estates in South Bank. Having no other alternative left to them, the estates combined sickling with the herbicide application to keep the areas as clean as possible. Frequent enquiries were made for new herbicides,

particularly to control weeds like thatch, *Polygonum chinense*, *Setaria palmifolia* etc. It was rather unfortunate that although a couple of new herbicides showed promising results in the trials conducted last year, these could not be recommended because of their nonavailability.

In Cachar, because of its short supply some estates were using more dilute solutions of Gramoxone than normally recommended by Tocklai. This was done just to cripple the weeds during the growing season and the results appeared to be satisfactory.

In the North Bank, some companies were trying their own cocktails of different herbicides. However, the Advisory Officer stressed on the use of the proven cocktails recommended by Tocklai.

In general, estates in Dooars and Terai made good progress in chemical weed control. Many estates in Dooars and Terai tried using the herbicides at less than the recommended rates, but the results were far from satisfactory in the long run. The herbicides most commonly used were Gramoxone, 2,4-D, Dalapon and Ansar 529, though the last mentioned herbicide was not recommended by Tocklai. The use of Simazine was popular in the nursery. The resistant weeds, like *Polygonum spp.*, *Diascoria spp.* were removed by hand. In Darjeeling, a few estates carried out chemical weed control.

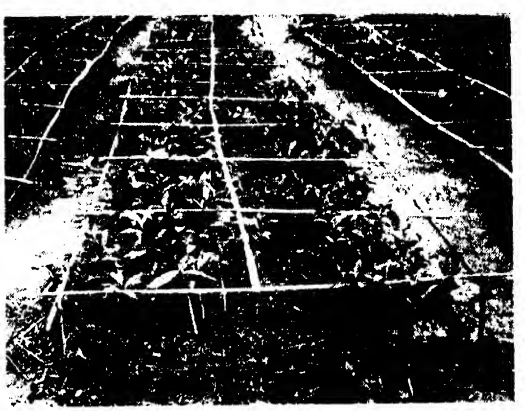
Mulching

In addition to Guatemala, Napier and *Mimosa invisa*, use of processed Citronella leaves for mulching young tea was found to become popular in Assam. Where mulching material was in short supply, estates went in for paddy straw etc. with an additional dose of 20 kg N/ha as recommended by us. Use of other materials like water hycinth, wherever available, was also noticed.

In the Dooars and Terai, most estates tried their best, to mulch their young tea areas. It was made known to the estates that besides giving nutritional benefits, mulch was the first line of defence against drought effects.

Shade

Indigofera teysmanii continued to be the predominent temporary species in all areas. A close spacing was advocated for this species. However, the estates were advised to lop the trees frequently during the growing season so that at no time the shade becomes too heavy. In Darjeeling, this species was used successfully in a few estates at lower elevations i.e. below 700 metres.



Tramline Pegging

In Assam and Dooars, the most favoured permanent species were *Albizzia odoratissima*, *Albizzia lebbek*, *Derris robusta*, *Acacia lenticularis*. Estates of Dooars and Terai reintroduced *Albizzia chinensis* as a shade tree. Estates, where *Dalbergia sericea* was introduced as a new shade in the South Bank, could not make full use of it, because of the difficulty in germination of seeds. It was heartening to note that in Cachar, the urgency of establishing permanent shade nursery for rehabilitating the existing poorly shaded areas was felt by some estates and accordingly, initiative was taken in this direction.

Limited availability of fire-wood forced some of the estates to go in for thinning out the existing shade trees in tea areas. It was, however, advised to thin out judiciously only those areas where the shades were heavy. It was also stressed that fire-wood supply to the labourers should not be the overriding factor for thinning out shade from tea areas.

In the Dooars and Terai, unshaded and poorly shaded sections were invariably found to be susceptible to red rust and mite attacks. The incidence of sunscorch damage to branches was also high in some such sections.

Shade is generally not recommended in Darjeeling at elevations higher than 700 metres. However the advisory officer had found it useful for estate, to establish a light shade in mid elevations, especially in southern and western aspects because it reduced drying of soil during the drought period, tended to check landslides and reduced the incidence of mites.

Pests & Diseases

(*a*) **Pests :** In Assam, insects like looper, bunch caterpillar, green fly, etc., were seen during the first and the last quarter of the year under review (i.e. April 1974 and March 1975) in the South Bank.

With the continuation of droughty period in early 1975, red spider and other mites were on the increase. Prophylactic spraying against mites continued and more rounds of palliative spraying had to be given during early 1975 to keep mites under control

Microcerotermes (livewood eating termites) continued to be a major pest in Cachar district and it was stressed by the Advisory Officer to use insecticides to control this pest. Some of the progressive estates, however, started spraying against this pest.

In the Dooars and Terai, the incidence of red spider was less than in the previous year. However, scarlet and purple mites were in abundance in many estates. Thrips, helopeltis, red slug, looper and cockchafer were noticed in a few estates and they caused a considerable loss in crop.

In Darjeeling, red spider and other mites continued to pose problems to those estates which did not take timely action against these pests. Helopeltis was on increase and a few estates were badly affected by this pest during October and November. Jassids and thrips also caused considerable damage, but these were controlled after the quality period was over.

(*b*) **Diseases :** While red rust and black rot were on the increase in South Bank, regular and timely spraying of copper fungicide as well as ameliorating the predisposing causes continued to be a part of our advice. In the North Bank there was a satisfactory trend in the reduction of red rust incidence. Whereas, in Cachar it continued to be a problem in the flat areas where drainage was not adequate.

The primary root diseases were a great problem in the North Bank. Members were reminded about the seriousness of the disease during advisory visits. In the South Bank, red root rot (*Poria hypolateritia*) was observed for the first time in one estate in Upper Assam.

In the Dooars and Terai, red rust and black rot were the common diseases, but their incidence was less than the previous year. Blister did considerable damage to tea in Darjeeling, because in most cases adequate control measures were not taken. Planters felt that a good 'sticker' would be of great help while spraying against this disease during rain. In fact, a few estates tried "Triton" on their own and claimed to have obtained satisfactory results.

Advisory Out-Station Plots & Experiments

The plots at the outstations and at Tocklai were maintained for distribution of cuttings of Tocklai release clones to the member estates.

(*a*) **General :** Bushes in the plots at Nagrakata were severely affected by the unprecedented drought during 1974-75 cold weather. The damage gas extensive and serious, particularly in unpruned plots where a number of bushes died. There were significant variations between clones planted in those plots with respect to drought resistant characteristics. Clones TV1, TV12, TV14, TV16 & TV17 were generally found to be fairly drought resistant. Whereas, TV18 and TV9 were severely affected by the drought in some plots.

(*b*) **Release of Tocklai Clones :** The details of distribution of cuttings, scions, generative clones and seeds from various Outstations and Tocklai to member estates are given in Table 2.

Table 2. Distribution of cuttings, scions, generative clones and seeds from various Outstations and Tocklai

Outstations	V.P. Cuttings	Scions	Generative cuttings	Generative scions	Plants	Seed
South Bank (Tocklai)	513969	3598	..	..	..	..
North Bank	153490	1690	—	..	20	..
Cachar	179505	50	—	..	210	..
Dooars & Terai	690040	1745	13900	230	—	5 Units of stock 378

(*c*) **Establishment of new clones at Nagrakata for future release :** Scions of 3 clones were brought from Tocklai and grafted on TV10 bushes in June 1974, for the purpose of multiplication. These three clones were, 4/6, 124/41/41 and 124/53/25. The grafting was successful in respect of all the three clones and it is anticipated that a good number of cuttings will be available in 1975.

(*d*) **Green Leaf :** Green leaf harvested from different outstation plots are stated below :

North Bank	..	3383 kg
Cachar	..	4430 kg
Nagrakata	..	25770 kg

(*e*) **Experiments :** Look-see plucking trial, which was laid out in the advisory plot in Cachar and reported in the Annual Scientific Report 1973-74, Page 13, continued during 1974. All the plots were left unpruned in 1974. Tea plucked at 20 cm, following the top prune during 1972-73 cold weather, gave the highest yield. The second best treatment was tea plucked at 10 cm and then raised by another 10 cm in early August 1973 following a top prune. The lowest yield was obtained from the treatment in which tea was plucked initially at 15 cm and then raised to 20 cm in early August, 1973 following a top prune in the previous cold weather. This trial will be continued to complete the pruning cycle.

The following trials were in progress at Nagrakata Branch.

(i) Agricultural trials with different clones (1967/68).

(ii) Agricultural trials with different clones (1973/74).

(iii) Nitrogen response to different clones (1970/71).

(iv) Biclonal stock trial (1974/75) with stock 460, 461, 462, 463, 464, 449 (already released), 378 (Nanda Devi—already released for estates in Darjeeling) and Clone TV 1.

(*f*) **Quality Testing Scheme (Dooars) :** Four clones were offered for testing during 1974 and these were planted out in the plots in autumn 1974. Besides these, pretreated cuttings of five clones were received from four estates in Cachar.

Routine work continued in the 1969-70, 1971 and 1973 trials.

Clonal Proving Station, Darjeeling (Ging T.E.)

(*a*) **Trial B, C, D, E & F :** Yield records were maintained and observations on growth were continued. A total of 1,178 samples were manufactured during the year.

(*b*) **Trial G :** This trial was planted with seven clones during the year under review.

37 clones and two biclonal stocks were under trial at the Clonal Proving Station. Their yielding capacity and cup characters were being compared with Nanda Devi biclonal standard and a nearby China hybrid section of Ging Tea Estate.

(*c*) **Factory :** Some modifications were made in the miniature factory at Nagrakata to improve drying. The factory at Ging Tea Estate was in full operation from the start of the 1974 season.

Field Experiments on Tea Estates

During 1974, twenty two experiments on three aspects, viz., rejuvenation, infilling and plucking, were laid in the estates of Assam and Darjeeling.

A complete and detailed list of experiments, conducted by this Department, is given in Appendix A.

The number of experiments conducted in various districts during 1974-75 is given below.

South Bank	..	20
North Bank	..	12
Cachar	..	12
Dooars & Terai	..	32
Darjeeling	..	13

Yield Survey

A survey was undertaken in the estates of Darjeeling by the Statistics Department in October 1974, in collaboration with this department.

Area Scientific Committee Meetings/Seminars

There are nine Area Scientific Committees in the tea districts of North-East India. The number of meetings held in the various districts is given below.

South Bank East	..	2
South Bank Central	..	1
South Bank West	..	3
North Bank East	..	2
North Bank West	..	2
(Joint meeting of North Bank East & West)		1
Dooars	..	3
Terai	..	2
Darjeeling	..	3
Cachar	..	2
Joint Area Scientific Committee Meeting	..	1

With the Area Scientific Committee meetings, open sessions were also held for the planters of the area to discuss the local problems. These proved to be useful platforms for free exchange of ideas between the planters and the Scientific Staff. These open sessions were very well attended. The details of the Seminars held during 1974-75 are given below.

South Bank East	: One seminar on plucking
South Bank Central	: One seminar on plucking
South Bank West	: One seminar on plucking
North Bank East	: One seminar on pruning
Cachar	: One seminar on drainage and One seminar on Manufacture
Dooars	: One seminar on plucking

Lecture Courses

Three courses, each of five days duration, on "Surveying & Drainage" for the planters and one course of three days duration on "Drainage" for the Government Approved Surveyors were held during the year. The courses were well attended.

Three short lecture courses on various aspects of tea were held at tea district clubs and one short lecture on nitrogen manuring was arranged at Tocklai during the period.

Summary of Results

Summaries of a few interesting experiments, conducted by the Department, are given below.

(*a*) **Infilling Experiment in Dooars and Terai (Nos. D. 37, D. 40, D. 41, TR. 3 & TR. 4):** Combined analysis of the five infilling experiments, conducted in the Dooars and Terai from 1969, showed that in 1974, the increase in yield due to infilling the vacancies (done in 1969) in mature tea was, in general, significant over no infilling (Table 3). Infilling with Clone TV 9 in a hedge at 3 plants per vacancy (T_5) increased the yield by 15.2 per cent, followed by 9.5 and 9.1 per cent increase from single infilling per vacancy with seedlings and clones respectively over control (Table 3).

Table 3. Average yield of made tea during 1974

Treatment	Made tea in kg/ha
No infilling (T_1)	1772
Infilling with seedlings at 1 plant per vacancy (T_2)	1941
Infilling with clone TV 9 at 1 plant per vacancy (T_3)	1931
Infilling with seedlings in a hedge, i.e. double the number of plants per vacancy plus one (T_4)	1891
Infilling with clone TV 9 in a hedge, i.e. double the number of plants per vacancy plus one (T_5)	2042
L.S.D. (P .05)	119
(P .01)	163
C.V. (%)	6.7

(*b*) **Nitrogenous Manuring Experiment in Dooars (No. D. 33) :** This experiment was started in 1966 in the Dooars on sandy loam soil and the results for 1974 are presented in Table 4. From the table (Table 4) it can be seen that 220 kg N/ha in eight equal applications (T_8) produced significantly higher yield over all the other treatments except 110 kg N/ha in two equal applications (T_4). However, all the treatments except 110 kg N/ha in four equal applications (T_6) produced significantly higher yield over no nitrogen (T_1).

Application of potash (*a*) 200 kg K_2O/ha failed to increase yield over no potash application.

Table 4. Average Yield of Made Tea during 1974

Treatments	Made Tea in kg/ha
No fertilizer (T_1)	2311
110 kg N/ha in one application (T_2)	2696
220 kg N/ha in one application (T_3)	2674
110 kg N/ha in two equal applications (T_4)	2790
220 kg N/ha in two equal applications (T_5)	2727
110 kg N/ha in four equal applications (T_6)	2658
220 kg N/ha in four equal applications (T_7)	2679
220 kg N/ha in eight equal applications (T_8)	3111
L.S.D. (P .05)	351
C.V. (%)	7.7

(*c*) **Clonal response to nitrogen in Dooars and Cachar (D. 24 & C. 20):** As in the previous years TV 18 gave significantly higher yield than all other clones during 1974. TV 1 followed TV 18 in its performance and was superior to TV 2 & TV 3.

In Dooars, all the clones under different doses of nitrogen produced significantly higher yield over no nitrogen. When the rate of nitrogen was raised from 55 to 110 kg/ha, the yield of clones TV 2, TV 18 and 3/22 increased significantly. There was, however, no appreciable gain in yield from all the clones, when the nitrogen dose was raised from 110 to 165 kg/ha.

The main effect of nitrogen and interaction between clones and nitrogen were not significant in Cachar.

(*d*) **Pruning cycle & severity of skiff (Dj.24):** During 1974, out of the twelve various pruning cycle treatments, three were light pruned, six were level-off-skiffed, two were deep skiffed and one remained medium skiffed. Level-off-skiff produced significantly higher yield over light prune, deep skiff and medium skiff. However, there was no significant difference in yield between deep and medium skiff treatments.

The periodic crop distribution under different forms of skiff showed that lighter forms of skiff produced more early season crop as well as the whole season crop in 1974.

(e) **Foliar Application of Zinc :** *Results of the twelve experiments conducted during 1974 at twelve different sites in Assam (including Cachar), Dooars and Darjeeling showed that application of zinc @* 50 kg/ha increased the yield by 5.5 per cent over no zinc, followed by 3.2 per cent and 2.4 per cent from 12.5 and 25.0 kg/ha respectively (Table 5). This increasing trend in crop outturn was observed in all the regions. The same quantity of zinc was applied in four equal instalments during the growing season. 1974 was the first year of the experiment when the tea was deep skiffed.

Table 5. Average yield of made tea during 1974

Treatment		Made Tea *in kg/ha*	*Percentage increase over no Zinc*
50 kg zinc/ha	(T_4)	2100	5.5
12.5 kg zinc/ha	(T_2)	2054	3.2
25 kg zinc/ha	(T_3)	2040	2.4
No. zinc	(T_1)	1991	—
L.S.D. (P .05)		N.S.	
C.V. (%)		8.1%	

'N.S.' = not significant.

Planting and Spacing

The three experiments on spacing, viz., B 8/1, B 8/2 and B 104 continued in 1974. A new experiment on spacing in fan design was planted in July 1974. In this experiment spacings ranging from 15 cm square to 150 cm square are being studied. B 8/1 is a factorial experiment started in 1966 with four spacings, two clones (TV 1 and TV 9) and three levels of nitrogen. In this experiment no interaction of spacing with clone and nitrogen was observed. The main effect of spacing is given in Table 1.

Table 1. Effect of different spacings on yield of made tea (kg/ha)

Treatment \ Year	1973 LP	1974 DS
120 cm × 22.5 cm	1687	2215
120 cm × 30 cm	1441	1882
120 cm × 45 cm	1462	1875
120 cm × 90 cm	1166	1639
C.D. at P. 05	271	261
C.V. %	22.1	16.1

The yield trend is the same in both the years. The closest spacing gave the highest yield and the widest spacing gave the lowest yield.

The other experiment (B 8/2) on jat tea was started in 1966 and the following results were obtained (Table 2).

Table 2. Effect of different spacings on yield of made tea (kg/ha)

Treatment \ Year	1973 LP	1974 DS
120 cm × 120 cm	1042	1505
120 cm × 90 cm	1115	1635
120 cm × 90 cm (doubleton)	1182	1703
120 cm × 75 cm	1094	1562
120 cm × 60 cm	1198	1682
120 cm × 75 cm × 75 cm	1281	1844
C.D. at P.05	127	155
C.V. %	7.3	6.2

It is interesting to note that 120 cm × 75 cm × 75 cm spacing gave the highest yield and was significantly better than 120 cm × 60 cm spacing, although the plant population in these two spacings was approximately the same (13675 and 13888 respectively).

In the other experiment (B 104) planted in 1957 the effect of different spacings on yield was not significant.

Plucking

The results of the plucking experiment (B 112/1) were reported earlier. The up to date results are recorded in Table 3.

Table 3. Effect of plucking methods on yield of made tea (kg/ha)

	Without broken back leaf			With broken back leaf		
Treatment \ Year	1972 LP	1973 UP	1974 UP	1972 LP	1973 UP	1974 UP
T_1- Pluck black to janam	1851	2701	2831	1851	2701	2831
T_2- Pluck standard leaf no breaking back	1325	1948	2143	- -	- -	- -
T_3- Pluck standard leaf and break back to janam	1312	1623	2221	1838	2338	2708
T_4- Pluck standard leaf over fish leaf no breaking back	1169	1708	2104	-	-	-
T_5- Pluck standard leaf over fish leaf break back to level off	1240	1721	1942	1617	2214	2442
C.D. at P. 05	131	174	183	134	163	166
C.V.%	6.9	6.5	5.9	6.2	5.4	4.9

Broken back leaf in treatments T_3 and T_5 was recorded separately. Yield records of treatments with and without broken back leaf are given in

table 3. Fish leaf plucking gave lower yields than *janam* plucking. When yields, inclusive of the broken back leaf were compared, no significant difference was found between T_1 and T_3 in the pruned year (1972) whereas in the first unpruned year (1973) black plucking gave significantly higher yield than standard plucking. Again, in the second unpruned year (1974) the difference between these two treatments was not significant.

Manuring

A number of experiments on different aspects of manuring are being conducted at Borbhetta. The results of some of these experiments are briefly discussed below.

Nitrogen Manuring : A critical study of some of the experiments on nitrogen manuring showed that nitrogen dose beyond a certain level might be harmful in the long run. This phenomenon was very clearly brought out from the results of experiment No. B 8/1 on unshaded clonal tea. In this experiment 100, 200 and 300 kilograms of nitrogen per hectare were tried. The results are given in Table 4.

Table 4. Yield of made tea (kg/ha)

Treatment \ Year	1970 DS	1971 MS	1972 LS	1973 LP	1974 DS
100 kg N/ha	1098	1336	2148	1484	1990
200 kg N/ha	1331	1690	2516	1544	2066
300 kg N/ha	1360	1628	2438	1289	1659
C. D. at P. 05	N.S.	267	262	N.S.	226
C.V. %	27.3	23.3	15	22.1	16.1

These results show that 100 kg N/ha gave less yield than 200 and 300 kg/ha doses in 1970, 1971 and 1972 whereas the yields of 200 and 300 kg/ha doses were at par during this period. During 1973 although there was no significant difference amongst these three treatments 300 kg N/ha dose showed a declining trend in its yield. In 1974, the yields of 100 and 200 kg N/ha were at par and the 300 kg N/ha yielded significantly less than the above two doses.

Results from another long term experiment are represented graphically in Fig. 1. It is worth to note two points from the figure that, (i) yield increased

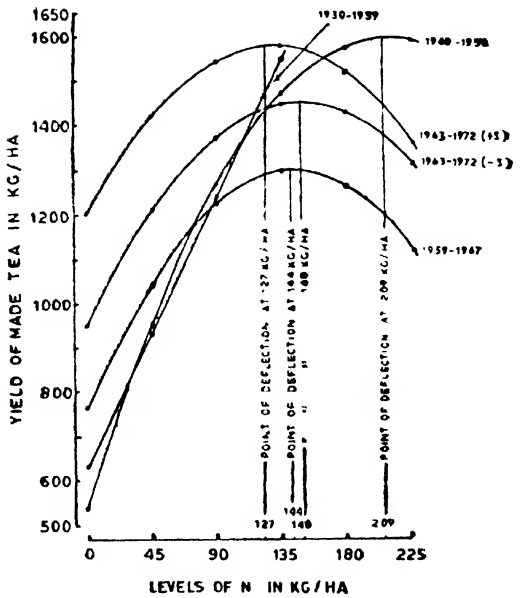


Fig 1. Response curves for nitrogen for different periods

upto a certain level of nitrogen beyond which it declined and (ii) the optimum level of nitrogen appeared to be a function of age. Tea in its earlier years responded to higher levels, but in later years the optimum dose came down to a much lower level.

Phosphate Manuring : In one experiment where phosphate was applied as superphosphate from 1960 onwards at 0, 45, 90 and 180 kg P_2O_5 per hectare on Clone TV 2, it showed a depressing effect on crop upto 1970. The trend of response changed from 1971 which can be seen from the data in Table 5.

Table 5. Effect of different levels of phosphate on the yield of made tea (kg/ha)

Treatment \ Year	Mean 1967-69	1970 LP	1971 DS	1972 MS	1973 LP	1974 DS
No Phosphate	1395	1588	1708	2467	1697	1865
45 kg/ha	1391	1576	1744	2562	1730	1977
90 kg/ha	1401	1493	1790	2675	1796	2067
180 kg/ha	1325	1374	1680	2594	1706	1975
C.D. at P. 05	—	109	NS	NS	NS	117
C.V %	—	10.2	10.2	9.1	8.6	8.4

Application of P_2O_5 as single superphosphate did not affect the crop yield significantly except in 1970 and 1974. The adverse effect of 180 kg P_2O_5/ha was noticed in all the years till 1971. A change in trend to phosphorus response was observed from 1972 onwards when all the three levels of phosphate application showed beneficial effect on the yield. Highest response was, however, obtained from 90 kg P_2O_5/ha and in 1974 it was significant. This reversal in the trend of phosphorus response may be due to the effect of chemical weed control and/or to foliar application of Zinc sulphate. In East Africa, response to P_2O_5 was obtained in tea under chemical weed control and this was attributed to the development of a mass of surface feeder roots. Another possible reason could be the interaction of Zinc and phosphate. In this experiment regular application of Zinc sulphate was started in 1970.

Another experiment was started in March, 1973 to study the effect of mulch and chemical weed control on response to phosphate fertilization. The results are given in Table 6.

Table 6. Effect of phosphorus, mulch and weed control on the yield of made tea (kg/ha)

Treatment		Year 1973 LP	1974 DS
Phosphate	No P	1468	2140
	50 kg/ha	1474	2214
	100 kg/ha	1463	2186
	150 kg/ha	1506	2181
	200 kg/ha	1480	2182
Mulch	No Mulch	1480	2162
	Guatemala mulch	1477	2200
Weed Control	Check	1483	2173
	Chemical Weed Control	1473	2188
	C.D. at P. 05	N.S	N.S.
	C.V. %	8.5	7.0

The tea was planted with Tingamira jat in 1961 and was well shaded. The ground cover was excellent. It is interesting to note that in both the years none of the treatments affected yield significantly. In other words, neither mulch nor chemical weed control affected the phosphate response. The possible reason for this might be that both mulch and chemical weed control take time to encourage development of surface feeder roots and only then, they can influence the response to phosphate.

Potash Manuring : In one experiment where potash was applied from 1960 onwards at 0, 45, 90 and 180 kg/ha on Clone TV 2, the response to potash showed some interesting trends. The mean yields for the last two pruning cycles and for 1973 and 1974 are given in Table 7.

Table 7. Effect of different levels of potash on the yield of made tea (kg/ha)

Year / Treatment	1967-69 LP DS-MS	1970-72 LP-DS-MS	1973 LP	1974 DS
No potash	1181	1636	1495	1671
45 kg/ha	1311	1931	1779	1933
90 kg/ha	1430	2019	1803	2054
180 kg/ha	1590	2114	1854	2171
C.D. at P. 05	132	115	106	117
C.V. %	13.5	8.3	8.6	8.4

The results indicate that response per kg potash was more in the earlier years of potash application. Later, when the potash level in the soil and plant was built up, there was no benefit from application of high doses of potash.

Micronutrients

Zinc : The results of the experiment (B 108. 1/2) started in 1970 are recorded in Table 8.

Table 8. Effect of zinc sulphate on the yield of made tea (kg/ha)

Treatment / Year	1971 UP	1972 LP	1973 DS	1974 UP
$ZnSO_4$ 24 kg/ha	2383	1932	2117	3038
Water spray	2204	1756	2016	2896
C.D. at P.05	Sig.	N.S.	N.S.	N.S.
C.V. %	9.2	15.0	14.7	12.4

Significant response due to application of Zinc sulphate was recorded only in 1971. The increase in yield during subsequent years was not significant.

Another experiment on Clone TV 9 was started in 1973 to determine the level, method and frequency of application of Zinc sulphate on mature tea. The experiment has to be continued for at least 3 years to get the required information. The results to date are given in table 9.

Table 9. Effect of different levels, methods and frequencies of zinc sulphate application on yield of made tea (kg/ha)

Treatment	Yield	
Year	1973	1974
T_1—Control	961	1346
T_2 12.5 kg $ZnSO_4$/ha foliar application annually	1031	1429
T_3 25.0 kg $ZnSO_4$/ha foliar application annually	1052	1471
T_4 12.5 kg $ZnSO_4$/ha foliar application once in 3 years (1974)	949	1387
T_5—25.0 kg $ZnSO_4$/ha foliar application once in 3 years (1974)	944	1329
T_6 25.0 kg $ZnSO_4$/ha soil application annually	990	1268
T_7 50.0 kg $ZnSO_4$/ha soil application annually	977	1363
T_8 25.0 kg $ZnSO_4$/ha soil application once in 3 years (1974)	966	1332
T_9 50.0 kg $ZnSO_4$/ha soil application once in 3 years (1974)	970	1433
C.D. at P.05	N.S.	N.S.
C.V. %	11.6	9.7

No significant difference amongst treatments was found in 1973 and 1974. The treatments were grouped into foliar and soil application and statistically analysed. In 1973 foliar application of Zinc gave higher yield than soil application, but in 1974 there was no significant difference in yield between foliar and soil application.

Long Term Agricultural Trial of Tocklai Clones

A long term agricultural trial was started with some Tocklai released clones in 1966 to study their relative yield performance. The yield data of these clones for the last three years are recorded in Table 10.

Chemical Weed Control

The following herbicides underwent preliminary screening trials.

Table 10. Yield of made tea (kg/ha) of some Tocklai released clones

Clone	Made tea in kg/ha		
Year	1972 MS	1973 LP	1974 DS
T.V. 1	1549	1782	1636
T.V. 2	1275	1205	1182
T.V. 4	1712	1912	1734
T.V. 7	1691	1935	1579
T.V. 8	1589	1653	1598
T.V. 9	1604	1988	1672
T.V. 10	1782	1859	1821
T.V. 11	1731	1931	1848
T.V. 12	1437	1577	1589
T.V. 14	1908	1976	1986
Betjan	1600	1530	1608
C.D. at P.05	236	310	246
C.V. %	10.6	12.9	10.3

Sirmate : Sirmate was tried both as pre and post emergent application at 5, 10 and 15 l/ha on broad leaved weeds. It gave excellent control as pre emergent spray at 5 l/ha, but for effective post emergent control 15 l/ha was required. It had no effect on *Imperata cylindrica*.

Roundup : Detailed report on Roundup was published in the Annual Scientific Report 1973-74, pp 21-22. Roundup was tried against *Cynodon dactylon* at 1.5 and 3.0 l/ha. Good control for a two month period was obtained even at 1.5 l/ha.

Ammonium sulphamate : This herbicide was tried last year at 15, 30 and 60 kg/ha. Weed control was very poor. It was tried again at 75, 100 and 125 kg/ha. The weeds in the area were, *Borreria hispida*, *Commelina benghalensis*, *Paspalum* sp., *Saccoharum spontaneum*, *Hydrocotyle asiatica*, *Colocasia* sp., *Urena lobata* and *Erechtites valerianaefolia*. Ammonium sulphamate had immediate scorching effect on weeds and this effect lasted for a fortnight only. Repeat application at the same rates was given 25 days after the first

application. The weeds, *Borreria hispida*, *Urena lobata* and *Erechtites valerianaefolia* were controlled, but within four weeks there was complete reinfestation.

Addition of Urea to 2,4-D : A trial was conducted to find out if addition of Urea to 2,4-D increased the effectiveness of weed control. Spraying was done on 14.5.74 and the results are recorded in Table 11.

Table 11. Effect of 2,4-D in combination with urea on weed control

Treatment	Visual score on weed control in per cent by date								
	17/5	21/5	28/5	4/6	11/6	18/6	25/6	2/7	9/7
2,4-D @ 0.5 kg/ha	5	20	50	65	70	70	55	35	30
2,4-D @ 0.5 kg/ha + Urea @ 0.5 kg/ha	5	30	85	90	100	100	92	90	90
2,4-D @ 1.0 kg/ha	10	40	85	90	100	100	92	90	90
2,4-D @ 1.0 kg/ha + Urea @ 1.0 kg/ha	10	40	90	99	100	100	95	95	90

Addition of Urea increased the effectiveness of 2,4-D at the lower dose of 2,4-D, i.e. @ 0.5 kg/ha.

Check Test & Certification : Two brands of the Sodium salt of 2,4-D, namely Phen-D manufactured by Messrs New Industrial Chemicals, Calcutta and 2,4-D Sodium salt manufactured by Messrs Chemical Organics, Cuttack were check-tested and given Certificates of approval.

Experiments on Quality

Effect of different levels of phosphate and potash on quality : Leaf from four treatments of a manuring experiment at Borbhetta was manufactured on 16 occasions during 1973 and 1974. These were tasted at Tocklai to find out the effect of different levels of phosphate and potash on the strength, quality and valuation of C.T.C. teas. The results are given in Table 12.

Table 12. Taster's average score on strength, quality and valuation of C.T.C. teas for various treatments by year

Year			1973 (LP)			1974 (DS)		
Treatment			Strength	Quality	Valuation	Strength	Quality	Valuation
N.	P.	K.						
135	0	0	68	66	6.34	75	76	6.81
135	180	0	68	66	6.30	74	74	6.76
135	0	180	68	65	6.28	73	72	6.61
135	180	180	64	63	6.17	71	71	6.59
C. D. at P. 05			N. S.	N. S.	N. S.	N. S.	N. S.	N. S.

In this experiment the manuring treatments were applied continuously for 13 years on clonal tea. It is evident from the data that application of phosphate and potash did not affect the strength, quality and valuation of C.T.C. teas.

Effect of Foliar Application of Zinc Sulphate on Quality : There were two treatments in this experiment, i.e., water spray and spray of Zinc sulphate four times at 6 kg/ha on each time at 2 months interval. The tea was manufactured in 1 kg rollers by C.T.C. method on 22 occasions during 1973 and on 22 occasions each by C.T.C. and Orthodox methods in 1974. The samples were tasted by Tocklai Taster. The results are tabulated in tables 13 a, 13 b and 13 c.

Table 13 a. Taster's average score on strength, quality and valuation of C.T.C. teas for 1973

Treatment	Strength	Quality	Valuation
Water spay	66	63	6.18
$ZnSO_4$ spray	62	57	5.90
C.D. at P.05	N.S.	N.S.	N.S.

Table 13 b. Taster's average score on strength, quality and valuation of C.T.C. teas for 1974

Treatment	Strength	Quality	Valuation
Water spray	74	73	6.66
$ZnSO_4$ spray	67	69	6.42
C.D. at P. 05	5.44	N.S.	N.S.

Application of Zinc sulphate did not affect the strength, quality and valuation of C.T.C. teas in 1973. But in 1974 the score for strength was significantly lower in Zinc sulphate treatment than water spray. There was no difference in quantity or colour of tip, strength, quality, briskness and valuation between Zinc sulphate and water sprayed plots for the orthodox teas in 1974.

Borbhetta Field Experimental Estate Report

Labour : The average daily attendance of labourers during the last five years is given below :

Table 13 c. Taster's average score on various characters and valuation of Orthodox teas for 1974

Treatment	Quantity of Tip	Colour of Tip	Strength of Liquor	Quality	Briskness	Valuation
Water spray	59	51	67	65	40	5.46
$ZnSO_4$ spray	57	51	68	67	39	5.55
C.D. at P.05	N.S.	N. S.	N. S.	N. S.	N. S.	N. S.

Year	Number of labourers engaged
1970	188.30
1971	179.00
1972	183.00
1973	185.00
1974	190.00

Crop : The total yield of green leaf during the last five years is given below :

Year	Green leaf in kg
1970	1,72,868
1971	1,74,555
1972	2,26,455
1973	2,14,882
1974	2,62,751

Out of the total 1974 crop 2,57,530 kg green leaf was sold to Duklingia T.E. and the remaining was used for experimental purpose. General plucking was stopped on 6.12.74.

Nanda Devi Seed Bari : The seed produced from this bari was supplied to Darjeeling estates. The production of seed during 1973 and '74 is given below:

1973 .. 530 kg
1974 .. 740 kg

Soils and Meteorology Department

Studies on soil phosphate

To find out the fixation and release of freshly added and residual phosphates (from long-term manurial experiments) several soils have been exhaustively cropped in micropots using *Pennisetum pedicellatum* as the test crop. Phosphate was applied at the rates of 0, 60, 120 and 180 kg P_2O_5/ha to all the soils (freshly added) except those from the permanent manurial series. Soils from the permanent manurial series refer to long-term experiments at Borbhetta, viz, B/43 and B/105, receiving P_2O_5 at rates 0, 45, 90, 112 kg/ha from 1930 onwards, and at rates, 0, 45, 90, 180 kg/ha from 1960 onwards respectively.

During six months of intensive growth (June to November'74), no sign of exhaustion was observed either with reference to soil types or with levels of phosphate manuring included in this trial. Available soil phosphate and phosphate uptake by grass cuts increased progressively with the increasing rates of phosphate manuring. This was true for both freshly applied phosphate and the residual phosphate from long-term manuring. In manured soils the rate of release of phosphate from the different soils did not vary significantly, although the total uptake of phosphate by the test crop varied in the regional soils. This could be due to the variations in the capacity factor of the different regional soils, i.e., the wide variations in the native phosphate status of the different soils. An interesting feature in this experiment was the rate of release of the residual phosphate (soils from long term experiments), which was very much rapid compared to the freshly applied phosphate. This indicates that the phosphate residues of North East India tea area soils are not inert but a valuable source for meeting the nutritional requirement of the test crop.

Studies on soil potash

To examine the variabilities, if any, in potassium releasing properties of regional soils as well as soils from the long-term manurial experiments, several soils have been exhaustively cropped in micropots using *Pennisetum pedicellatum* as the test crop. Soils from the permanent manurial series, as in the case of phosphate experiment, refer to long-term experiments at Borbhetta, viz, B/43 and B/105, receiving K_2O at rates 0, 45, 90, 112 kg/ha from 1930 onwards, and at rates 0, 45, 90, 180 kg/ha from 1960 onwards respectively.

Uptake measurements carried out so far with several grass cuts during the period of active growth showed that the uptake of potash is linearly correlated with the exchangeable or available potash contents of soils irrespective of the regions. However, no sign of exhaustion was observed either with regional soils or with those from the permanent manurial series. Further, the rate of release of exchangeable or available soil potash from the soil matrix was much faster in the case of Darjeeling, Terai, and Brahmaputra Valley soils as compared to the soils from Dooars and Cachar.

The cumulative potash uptake by grass from those soils belonging to the permanent manurial series presents an interesting picture, viz., cumulative potash uptake (i.e., dry matter X potash concentration in a cumulative way) is much higher in the case of long-term manured soils as compared to their unmanured counterparts. This indicates that potash residues from long term manuring do not undergo fixation with clay minerals under North East India tea growing conditions. The cumulative potash uptake of regional soils also indicates that the quantum of withdrawal of available potash by grass cuts depends upon the available potash status of soils rather than any regional soil characteristics. This confirms our finding on the release of potash by treatment of soils with a cation exchange resin and subjecting the soil-resin mixture to laboratory incubations conditions (refer Ann. Sci. Rept., 1973-74, P. 29-30).

Studies on liming

For the second year in succession it was found that long-term application of lime resulted in appreciable improvement of stable soil aggregates in terms of both total and those above 2 mm in size dimension. No significant difference in soil aggregate status was observed between lime application at 2 and 4 tonnes per ha levels.

Studies on soil nitrogen

Nitrogen balance sheet was studied under greenhouse conditions to find out the fate of applied nitrogenous fertiliser in soil and plant, i.e., actual recovery of nitrogen (in the harvest, within the bush frame and roots), and losses through different channels.

The experiment was carried out in pots supporting 18 month old TV_1 plants. The pots received basal dressings of P_2O_5 and K_2O at rates 40 and 80 kg/ha respectively, and $ZnSO_4$ and Mg $S0_4$ at the rates of 20 kg/ha. The nitrogen treatments comprised of 0, 50, 100, 150 and 200 kg N/ha in the form of sulphate of ammonia. There were twentyfour pots under each nitrogen treatment, so that every two months four of the replicate pots could be taken out for destructive analysis with an aim to measure the total recovery of nitrogen. Leachates were collected every month subjecting the plants to simulated rainfall as that of Jorhat area, and were analysed for both ammonia and nitrate nitrogen contents. Changes in soil nitrogen content was monitored by analysing the soil initially and at the end of different periods of growth, viz., 2, 4, 6, 8, 10 and 12 months.

From the leaching loss and the nitrogen recovery estimated under experimentally controlled conditions at different periods of growth of young tea, the nitrogen balance sheet has been determined which is given in Table 1.

Nitrogen recovery at higher levels of application of nitrogen (150 and 200 kg N/ha) was about 10 per cent less than that of at lower levels of nitrogen application (50 and 100 kg N/ha). Further, it is noted that percentage recovery decreased with the increasing period of growth of tea plants.

It is also interesting to note that the percentage of applied nitrogen lost due to leaching does not vary significantly between levels of application of N, although net losses due to leaching increase with the increasing rates of nitrogen application. An important point that emerged from the balance sheet is that besides leaching loss of nitrogen, the gaseous loss of nitrogen can also be quite substantial, specially at higher levels of nitrogen application between 150 -200/N/kg/ha.

Table 1. Nitrogen losses due to recovery, leaching and escape in gaseous form at different levels of application

	Average over six sampling periods		
Level of nitrogen kg/ha	Per cent recovery by the tea bush	Per cent loss due to leaching	Per cent loss in the gaseous form 100 –(2)–(3)
(1)	(2)	(3)	(4)
50	51	40	9
100	54	38	8
150	42	38	20
200	42	38	20

It appears that timing of nitrogen application when the plant's need is maximum, and keeping the nitrogen level lower, could be the only possible ways to minimise leaching losses.

Cation exchange capacity (C.E.C.) of clonal tea roots

To investigate the effects of various growth promoting and growth inhibiting substances on root C.E.C., a sand culture experiment was carried out using clones TV_1 and TV_{18} which differed widely in respect of their root C.E.C.

(a) **Growth promoting substances**

Three growth promoting substances, each with three different levels were used, viz., giberellic acid (GA), indole-3-acetic acid (IAA), and 2,4-dichloro phenoxy acetic acid (2,4-D). The levels of application were 5, 25, and 100 p.p.m., corresponding to 8.5, 42.5 and 170 mg per plant respectively added during the course of the experiment.

Treatments with growth promoting substances were imposed after establishment of the plant which took about a month, and continued for 4 months.

Growth promoting substances at appropriate concentrations was applied weekly, whereas complete nutrient solution at full strength (Hewitt's) was applied daily to each potted plant.

After four months, plants were pulled out, aerial parts of the plants were cut off just above the root system, and the roots were used for measurements of root C.E.C., brown/white root ratio, and total O_2 uptake (only on white roots).

Table 2 shows the influence of different forms and levels of growth promoting substances on root C.E.C. of clones.

Table 2. Mean root C.E.C. (m.e./100 g dry weight) of clones TV_1 and TV_{18} as affected by different forms and levels of growth promoting substances

Form \ Level	5 p.p.m.	25 p.p.m.	100 p.p.m.	Mean
(1)	(2)	(3)	(4)	(5)
G.A.	18.26	20.01	21.45	19.91
I.A.A.	19.03	20.08	22.68	20.95
2,4 D	18.75	20.54	17.75	19.01
Mean	18.68	20.54	20.63	19.65

Highly significant difference between the different growth promoters in increasing the root C.E.C. at the concentration range 0 25 p.p.m has been observed. Indole 3 acetic acid had the maximum effect followed by G.A. and 2, 4-D. Both G.A. and I.A.A. increased root C.E.C. significantly when concentrations of the chemicals was raised from 0 to 5 and 5 to 25 p.p.m., but the rate of increase tended to slow down with further increase in concentration from 25 to 100 p.p.m. 2,4-D followed the same trend in the range 0 25 p.p.m but further increase from 25 to 100 p.p.m reduced root C.E.C. Interaction between clone and treatment has not been found to be significant.

As far as the brown/white root ratio is concerned, all the three growth promoters significantly reduced the ratio of both the clones, but IAA had the maximum effect, followed by GA and 2,4-D. The decline of brown/white root ratio, in general, has been progressive with the increase in the concentration of growth promoters.

It was also observed that the growth promoters significantly increased the total oxygen uptake by white roots of both the clones, but the three forms of growth promoters differed significantly between themselves. IAA showed the highest effect followed by GA and 2,4-D. The level of growth promoters also had significant effect on total oxygen uptake.

The interaction between clone and treatment in respect of brown/white root ratio and the total oxygen uptake by white roots was not significant.

Correlation study showed that root C.E.C. correlated negatively with brown/white root ratio and positively with total oxygen uptake by the white roots of clonal plants.

(*b*) Growth inhibiting substances

Three growth inhibiting substances each with three different levels were used. These were potassium Cyanide (KCN), sodium arsenate ($Na3AS\ 0_3$), and sodium azide (NaN3). The levels of application were 5, 25 and 100 p.p.m., corresponding to 8.5, 42.5 and 170 mg per plant respectively added during the course of the experiment. Other details and root measurements are same as those described in the case of experiment with growth promoting substances.

The influence of different forms and levels of growth inhibiting substances on root C.E.C. of clones is shown in Table 3.

Table 3. Mean root C.E.C. (m.e./100 g dry weight) of clones TV_1 and TV_{18} as affected by different forms and levels of growth inhibiting substances

Form \ Level	5 p.p.m.	25 p.p.m.	100 p.p.m.	Mean
(1)	(2)	(3)	(4)	(5)
MCN	15.56	14.39	11.86	13.94
$Na3\ AS\ 0_3$	15.95	15.23	13.17	14.78
NaN3	15.79	15.05	12.89	14.58
Mean	15 77	14.89	12 64	14.43

The root C.E.C. values decreased significantly with increasing concentration of growth inhibiting substances up to the level of 100 p.p.m. The differen-

ces between the three forms of growth inhibiting substances were, however, not significant. The interaction between clone and treatment was not significant.

Further, brown/white root ratio increased significantly with increasing concentration of growth inhibiting substances upto the level of 100 p.p.m. No significant difference in brown/white root ratio was observed between the three forms of growth inhibiting substances. The interaction between clone and treatment was also found to be not significant.

Measurements of total oxygen uptake by the white roots of both the clones (TV_1 and TV_{18}) after treatment with different forms and levels of growth inhibiting substances have shown that the total oxygen uptake decreased significantly with increasing concentration of growth inhibiting substances. The variances due to forms of growth inhibitor, clone, and clone X treatment interaction were not significant.

Correlation study showed that root C.E.C. correlated negatively with the brown/white root ratio and positively with the total O_2 uptake by the white roots of clonal plants.

Production of roots under regimes of weedicide and mulching

Feeder or absorbing root production under regimes of weedicide and mulching was followed for one full year at bi-monthly interval in experiment No. B 23/3 of the Agronomy Department. For the purpose of root study, only those plots which received phosphate at 0, 100 and 200 kg P_2O_5 /ha were included. Mulch and weedicide treatments comprised sub-plots under the different photsphate levels.

Pooled data of all the six occasions showed that feeder root production increased significantly under mulch treatment. The variances due to weedicide, and interaction between mulch X weedicide were not significant.

Table 4 shows the feeder root production at different periods as influenced by mulching and weedicide treatments.

The data also show a seasonal effect on the production of feeder roots irrespective of the cultural treatments. During the period of growth of tea flushes, i.e., from March to November, feeder root production decreased progressively, but from January to March, i.e., the period of dormancy, feeder root production proliferated once again, indicating thereby an opposing periodicity in flush and feeder root growth.

Root development under different spacing of tea

Three different spacings of tea, viz., 120 cm × 90 cm × 60 cm, 50 cm × 50 cm, and 22.5 cm × 22.5 cm were included for the present investigation, where the plant population have been 12,000, 33,000 and 1,30,000 plants per hectare respectively. The differently spaced fields carried clonal teas of the age group between 5-6 years. for the present study two clones, viz, N 436 and T106

Table 4. Feeder root production at different periods as influenced by mulching and weedicide treatments (kg/ha 7.5 cm soil)

Treatment	Period of sampling							
	March '74	May	July	Septr.	Nov.	Jany.	March '75	Mean
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Mulch	1254	1029	682	588	477	503	877	773
No mulch	956	619	500	413	439	441	729	585
Weedicide	1064	810	612	510	448	434	725	657
No Weedicide	1146	838	570	489	468	510	880	701
Mean	1105	824	591	501	458	472	803	

commonly occuring under all the three spacings were utilised. By and large, similar management practices were adopted for all the fields under different spacings.

Field observations comprised maximum root depth, effective root depth, lateral spread both along and across the hedge, and estimation of feeder or absorbing roots. Laboratory measurements were confined to counting number of primaries per plant, total linear growth of primary and secondary roots, maximum and minimum diameter of the roots, and finally the dry weight of the roots.

Results of field observations are given in Tables 5 and 6.

The difference between 22.5 × 22.5 cm and the other two spacings in respect of both maximum and effective root depths was highly significant, whereas the difference between the other two spacings was not. The progressive decrease of horizontal spread of the root system with increasing plant population was also found to be highly significant.

Further, feeder root production increased with closeness of spacing. The difference between 22.5 × 22.5 cm and the widest spacing in this respect was found to be highly significant. The difference between spacings 50 cm × 50 cm and 22.5 cm × 22.5 cm was not, however, significant. The mean values of eight epochs of sampling are shown in Table 6.

Table 5. Field observations on the development of the root system of clones as influenced by spacing of tea

*Mean ± S.E.

Spacings / Root growth characteristics	120 cm × 90 cm × 60 cm	50 cm × 50 cm	22.5 cm × 22.5 cm
(1)	(2)	(3)	(4)
Maximum root depth (in cm)	83.00 ± 1.71	86.00 ± 3.09	98.00 ± 1.63
Effective root depth (in cm)	68.00 ± 3.90	77.00 ± 2.67	86.00 ± 1.54
Horizontal spread of roots as radious (in cm)	59.34 ± 1.83	32.34 ± 1.20	23.62 ± 2.99

* Figures represent mean of eight observations with the standard errors.

Table 6. *Mean feeder root production (kg/ha) under different spacings

Spacing	Feeder roots (on dry weight basis) mean of eight epochs.
(1)	(2)
120 cm × 90 cm × 60 cm	8816.72
50 cm × 50 cm	9128.99
22.5 cm × 22.5 cm	10,817.00

*each epoch comprises twenty core sample of roots - thus the above data are mean of 8 × 20 = 160 core samples.

Under the closest spacing, i.e., 22.5 cm × 22.5 cm, presence of a substantial quantity of feeder roots was marked down to a depth of 90 cm, although concentration of feeder of absorbing roots was found to be maximum within 60 cm soil layers.

So far as the laboratory measurements are concerned, it was observed that the number of primaries, total linear growth of primaries and secondaries, diameter of the primaries and secondaries, as well as the total dry matter weight of the root system per plant decreased progressively with the increasing plant population or closeness of spacing. Statistical analysis showed that the differences between the widest spacing, i.e., 120 cm × 90 cm × 60 cm, and the other two spacings in respect of all the above root growth parameters viz., length, diameter and dry weight were highly significant. However, total dry weight of roots per unit area increased significantly with closeness of spacings. Further, the shoot/root ratio increased with decreasing plant population, the ratio with 120 cm × 90 cm × 60 cm being double than those of either 50 cm × 50 cm or 22.5 cm × 22.5 cm spacing. A critical limit was also found at 50 cm × 50 cm or 33,000 plant per hectare, beyond which reduction in dry matter weight per plant top or root was not significant. Similarly shoot/

root ratio did not alter significantly above this critical limit of 33, 000 plants per hectare.

Soil Moisture depletion pattern under different spacings

The changes in soil moisture content was followed under the three spacings mentioned above all throughout 1973-74 and 1974-75 dry period, i.e., from November to March period. It was found that upto a population of 33,000 plants per hectare soil water depletion in dry period did not alter significantly, indicating once again the existence of the critical limit. However, beyond this critical limit the depletion of soil water increased in a highly significant way over the period November to March, the exploitable soil water (i.e. soil water within the root depth) decreased by 23 cm compared to the widest spacing, i.e., 120 cm × 90 cm × 60 cm. It was computed that because of increased root depth under closest spacing (22.5 cm × 22.5 cm), exploitable soil water increased by about 8 cm compared to the widest spacing, thereby indicating that 1/3rd of the increased soil water use under the closest spacing was possibly met from the sub-soil resources.

Studies on water table

As reported last year, tea bushes grown with water table fixed at 90 cm from the surface yielded significantly much higher crop than those having water table fixed at 135 cm throughout 1974. Repeated attempts to grow plants in the tanks with water table fixed at 45 cm from the surface indicate that when young healthy plants are transplanted in October/November, they pull through for a period of 6/7 months, i.e., until May/June, and thereafter, either packs up or remains in moribund condition. Attempts are now being made to find out clones that are resistant to water-logging by planting out different clones in tanks having water table at 45 cm.

Biuret toxicity

Biuret at 2, 4 and 6 per cent levels mixed with briuet free commercial crystalline urea and foliar sprayed at 5 per cent (V/V) spray concentration of urea at fortnightly intervals for the entire 1974 cropping season neither adversely effected yield nor exhibited any toxicity symptoms in the field. The variances due to treatment and treatment × season interaction have not been found to be significant.

Green leaf samples under various biuret treatments were also manufactured on eight different occasions and valued by Tocklai tea tasters.

The effect of biuret on the valuation of tea was not found to be significant.

Soil Survey

(*a*) **North Bank**

A survey was carried out in the tea areas of the Northern Bank of Brahmaputra, extending between Lakhimpur in the North East and Goalpara in the South West, and comprising about thirty tea estates, with a view to identify the problem areas in respect of drought. Broad soil type and rainfall maps were prepared basing on the textural data of the soil profiles and longterm rainfall data respectively. Besides, within the broad types, four problematic sand series were identified, each at Lakhimpur, Bishwanath, Borsola, and Mangaldai circles respectively which are likely to suffer more in the droughty period.

Besides, delineating the soil types or series, available water capacity (A.W.C.) of the root profile of mature tea under different soil types was also determined, the estimated values of A.W.C. are shown in Table 7.

Table 7. Available water capacity of broad soil types in the North Bank

Sl. No.	Textural type	Available Water Capacity in cm (in inches)
(1)	(2)	(3)
1.	Silty loam (All throughout)	22.5 (9 in)
2.	Loam (top layer) and silts loam (bottom layer below 30 cm	20.0 (8 in)
3.	Loam (all throughout)	17.5 (7 in)
4.	Sandy loam (all throughout)	14.8 (5.9 in)
5.	Sandy loam (top layer) and Silty (bottom layer below 30 cm)	16.3 (6.5 in)
6.	Loamy sand (all throughout)	13.3 (5.3 in)
7	Sand (all throughout)	3.0 (1.2 in)
8.	Loamy sand (top layer) and sand (bottom layer below 30 cm)	7.8 (3.1 in)
9.	Sandy loam (top layer) and sand (bottom layer below 30 cm)	12.0 (4.8 in)

Table 7 shows that in general, as the sand fraction increases in the profile A.W.C. decreases and, conversely, as the silt fraction increases A. W. C. increases in a significant way. Correlations have been worked out between P.C. available water and mechanical fractions like sand and silt, which showed highly significant positive correlation between silt and p.c. available water, and highly significant negative correlation between sand and p.c. available water, the regression equations being :

$$Y = 2.68 + 0.181 \times (r = 0.73)$$

and

$$Y = 18.91 - 0.168 \times (r = 0.77)$$

respectively, where Y= p.c. available water and × either p.c. silt or p.c. sand. Further, it was observed that organic matter contents of North Bank soils did not influenced the A.W.C. of the profiles appreciably.

(*d*) Darjeeling

A survey was carried out covering Kurseong/ Mahanadi, Darjeeling West, Darjeeling East and Rungbong Valley circles (each circle represented by three tea estates) with a view to find out the effects of elevation and aspect on the physico-chemical characteristics of soils, as well as to classify the broad textural types. There were three elevations viz., 914—1,219 m (3,000 4,000 ft), 1,219 1,524 m (4,000 5,000 ft) and above 1,524 m (5,000 ft), and two aspects viz., North East and South West.

The effects of both elevation and aspect on the soil organic matter content was found to be highly significant and these are shown in Table 8.

Table 8. Mean organic matter content of soils (p.c. on dry weight basis)

Elevation (in meter) / Aspect	914 -1,219	1,219 -1,524	Above 1,524	Mean
(1)	(2)	(3)	(4)	(5)
North East	5.33	5.52	6.26	5.70
South West	4.62	5.20	5.50	5.11
Mean	4.98	5.36	5.88	5.40

It can be seen from Table 8 that organic matter content increased progressively with increasing elevation upto 1,524 m or above, indicating, thereby, the effect of decreasing ambient temperature on the conservation of soil organic matter status. The deterioration of soil organic matter on the South west aspect could be due to the direct effect of insolation and resultant burning. The direct effect of these gains or losses of organic matter due to elevation and aspect respectively on the associated physico-chemical properties of soils are now being investigated.

As far as the broad soil types are concerned, Darjeeling soils can be classified under three main textural groups viz., sandy loam, loam and silty loam, with majority of the soils occuring under loamy type. Neither elevation nor aspect appears to influence the inherent textural character of the soils.

Research and Advisory analysis

About 60,000 soil tests were carried out during the year. The break-up is as follows :

(i) **Research :** For Soil's Department as well as for other Departments 15,000 estimations.

Advisory : For tea estates alone, 45,000 estimations.

Publication

S. K. Dey and H. Mitra, "Physical factors affecting tea production in North Bank", In a brochure on tea on the North Bank, published on the occasion of Joint Area Scientific Committee in North Bank, 1974.

Appointment

Messers. N.G. Bhattacharyya, and A.K. Sengupta have been promoted to the Officer's cadre as Assistant

Soil Scientists for Tocklai and Nagrakata Soil Testing Units respectively. Messers. C. K. Ramamohan and A. K. Das have been transferred to Nagrakata Soil Testing Unit. Miss R. Bora, Miss D. Saikia, Miss M. Baruah and Mr. J. Devnath have been appointed as Junior Research Assistant to fill in vacancies. Messers. A. K. Das, S. N. Talukder and J. N. Bora have been promoted to the Junior Laboratory Assistant's cadre from the sub-ordinate staff.

Honours and Higher Studies

Mr. G. Chamuah, who worked as a C.S.I.R. Junior Fellow in the Department, has been awarded the Ph. D. degree of the Assam Agricultural University for his thesis entitled, "Cation Exchange Capacity of Clonal tea roots and its implication to fertiliser practices".

Mr. N. Barpujari, an I.C.A.R. Scholar, has submitted his thesis entitled, "Influence of spacing of tea on moisture utilisation, root development and nutrient uptake" in partial fulfilment of M.Sc. (Ag) degree in Tea Science and Technology.

Miss. R. Bora and Mr. J. Devnath have obtained M.Sc. degree from Gauhati and Calcutta University respectively.

Mr. P. Ghosh has been sponsored for Post-graduate studies in Physics at the University of Gauhati.

Organisation

The project document entitled "Studies on Groundwater Drainage Problem at T.R.A.", prepared by the Department has been approved by the United Nations Development Programme and the Government of India, and, as a result, an Agricultural Drainage Expert will soon join the Department for a period of two years to lead and organise the drainage research under the UNDP Project.

Our long and concentrated efforts to make some headway in land planning have met with small success at long last. We have received topo sheets (scale 1 inch = 1 mile) for almost all the tea districts. On marking out the tea areas in the topo sheets we shall have to approach the Surveyor General once again, as well as the Defence Ministry for preparation of serial photographs at the centre for Survey Training and Map Production, Survey of India, Hyderabad.

The need for quick soil testing service in West Bengal has been fulfilled by construction of laboratory, procurement of essential equipment, glasswares, chemicals etc. and training of staff—the laboratory should be operating at full scale from the next year.

Two new weather stations have been organised once each at Terai and Margherita, the latter one in collaboration with Makum and Namdang Tea Co., Three observers have been trained for purpose of data recording in the newly started meteorological observatories.

Glasshouse facilities have been doubled up and several modifications brought in for carrying out nutritional experiments under controlled conditions, although we are not yet in a position to control fully excessive heat problem during the summer months.

Import of necessary equipment components was not possible due to restrictions and delay in issuing licenses, as a result of which several research projects could not be developed according to the time schedule.

Botany Department

Plant Improvement

Induction of Haploidy

Investigation is in progress at IARI. Initial observations showed varietal difference in callusing ability in culture media. However, no embryoids could be obtained in any of the varieties. Further work on standardization of the media is in progress.

Induction of Mutation

Observations were carried out on the seedlings raised from seeds and clonal cuttings irradiated with X-ray (Annual Scientific Report, 1972-'73, pp. 46-47; 1973-'74, pp. 43-44). None of the plants showed any sign of visible mutation.

A few experiments on the radio-sensitivity of the tea plant were also carried out at Long Ashton Research Station, U.K., by the Plant Breeder during his visit to the Institute in 1974. Single node cuttings from a few glass-house grown tea plants were subjected to acute gamma radiations from cobalt-60 sources. The doses were 0, 2, 4, 8 and 12 krads at 0.225 rads/sec. and 111.82/rads/sec. Cuttings were irradiated in dry condition and under water in order to determine the LD_{50} for tea under dry and wet condition.

Irradiated cuttings were grown in propagation beds under mist and observation on the percentage survival of cuttings were taken after 14 weeks. Results showed considerable variation in tolerance of tea cuttings to the rate of irradiation. The LD_{50} for fast exposures was about 3 krad both under dry and wet condition, whereas the LD_{50} for slow exposures was 6 krads and 10 krads under dry and wet condition respectively.

Clonal criteria

Data collected awaits statistical analysis. The objects of this study is to find out the morphological criterion or criteria, if any, associated with vigour and quality of a tea plant and thereby to help in clonal selection work.

Production of clonal seed

Out of the pollinations carried out in 1973-'74 (Annual Scientific Report, 1973-'74, p. 42) to screen out the combiner clones, most of the crossings done with TV 1 and TV 9 were successful. The percentage seed-set was generally high with TV 1 as a female parent in all the combinations, the average being 13.95 per cent. Whereas, the success with TV9 as a female parent was low in all the combinations tried, giving an average of only 6.32 per cent. The seedling raised from these seeds are under observation for their growth and uniformity. The selected stocks will be planted out in long term trial in 1975 winter.

Some more pollinations were done using six standard TV clones as female parent and three clones as the male parent. Altogether 1155 pollinations were done in 14 different combinations. Initial observations indicate that all the combinations are likely to be successful.

In the interspecific crosses attempted between tea and other related species (Annual Scientific Report, 1973-'74, p. 42), viable seeds were obtained only from the crosses with *C. japonica* and *C. kissi*. The seedlings raised from the crosses are under observation for their growth, vigour and morphological characters.

Production of Triploids

Altogether 22 seedlings were obtained from the 1973-'74 pollinations between the low quality vigorous tetraploids and high quality diploids. The seedlings are under observation for their growth and vigour. The selected bushes will be propagated for establishing fair-sized trial plots.

Some more pollinations were done this year using five high quality diploid clones.

Agricultural trial of clonal seeds

Observations were carried out on the various characteristics of the six biclonal and one polyclonal stocks planted out in the long-term trial. All the stocks were vigorous and uniform in their morphological characters. However, the plants are still very young and sufficient quantity of leaf was not available for manufacturing trials.

Trials on these biclonal stocks were started in the Dooars and Cachar towards the end of 1974 and are under observation, particularly for their drought resistant properties.

Seeds of the above stocks were also distributed to different agro-climatic regions for establishing large-sized observation plots.

Seeds from one biclonal stock for Darjeeling areas were sent to clonal proving station at Ging T.E. for long-term trial.

A few more biclonal combinations were selected for establishing micro seed baris to produce seeds under natural condition and their subsequent evaluation.

Preservation of Genetic resources of tea

Eleven clones of diverse morphological characters were added to the list of reserve stocks during the year.

Selection of vegetative clones

At present more than 100 clones are under various stages of selection in six long-term trials. Out of the completed trials, three clones were finally selected for release as soon as multiplication plots could be established.

Rooting trial was completed for 33 mother bushes selected during 1973-'74 from different jats. The seedlings of the successful clones are under observation for final selection of the clones for long-term trials. This will be planted in autumn 1975.

Selection work was also carried out in an old section of hybrid tea in a neighbouring estate. Thirty-one bushes were selected for evaluation of cup-characters and yield during the next season.

Management of shade

A brief report on the findings of shade pattern was reported in the Annual Scientific Report, 1973-'74, pp. 44-46. In continuation of those studies, the effect of shade on leaf temperature of tea bush and on quality of made tea are given below.

(*a*) **Shade and leaf temperature**

A stand of mature tea in the field consists of a dense canopy foliage between 20 to 40 cms thick about 1 meter above ground level. The relatively high Leaf Area Index of the crop, usually between 3 and 7, depending on the leaf pose of the type of tea, results in a high degree of self shading. This in turn implies that leaves in the canopy are subject to a different environment than those on bush surface.

The two major factors that affect leaf temperature are solar radiation and wind speed. From the results obtained so far it is clear that leaves deep in the canopy are exposed to a low radiation regime, and wind speeds usually less than 1.0 kilometer per hour. This relatively constant environment produces leaf temperatures that are very close to, but slightly below ambient dry bulb temperatures. The depression of leaf temperature is almost entirely due to the cooling effect of transpiration.

On the bush surface, however, conditions are very different as these leaves are exposed to extreme fluctuations of environmental factors. During the course of a single day, solar radiation may vary from 0 to 1.3 gram/cal/cm^2 /min^{-1} and wind speeds from 0 to 20 miles or more per hour. A 10°C a change in leaf temperature may occur within five minutes with concomitant changes in photosynthesis, respiration and transpiration rates. In Assam where most of the tea growing areas are in a sheltered valley, wind speeds are very low and during daylight hours, leaf temperatures of surface leaves are almost invariably above air temperatures in spite of transpirational cooling.

The effect of shade is mainly to reduced incident radiation on the bush surface and therefore reduce leaf temperatures. The degree of reduction depends on the density of the shade canopy and the temperature difference between shaded and unshaded leaves varies from 3 to 11°C. When shade tree foliage is sparse enough to allow small sunflecks to fall on the leaf as finely marked spots of light, its temperature is above that of air but below that of unshaded leaves. When direct light is completely intercepted (no sun-flecks) by a dense canopy of the shade trees, the leaf and air temperatures are generally very similar, with leaves usually slightly warmer than air. Heavily shaded tea bushes therefore, have all their leaves very close to air temperature throughout the day while upper leaves of lightly or unshaded bushes may be between 2 12°C above air temperature, depending on the wind speed and intensity of radiation.

In contrast to the conditions in South India, Sri Lanka, Malawi or Kenya prevailing during the harvesting season, in the Assam Valley wind speeds are generally very low with high relative humidity and ambient temperatures. Results from field and laboratory experiments show that wind movement, shade and transpiration cause a reduction in leaf temperature and that under conditions of high ambient temperatures the absence of wind movement may increase leaf temperature upto 14°C higher than air, causing leaf scorch and eventual death. An increase of relative humidity also affects the rate of transpiration.

In marked contrast to experience in most other tea growing areas, the beneficial effects of light shade on some types of tea bushes in Assam has been clearly demonstrated. The present study clearly shows that reduction in leaf temperature on the bush surface by the use of shade trees is primarily responsible for these benefits. It has also been shown that leaf temperatures are influenced by leaf pose and that under the environmental conditions of the Assam Valley some form of shading is necessary in the case of horizontal leaf types of tea bushes.

(*g*) Shade and quality of made tea

Along with the experiments at Murmuria T.E. on the effect of shade in reducing incident radiation thereby influencing the environment of the tea bush, a few experiments were also carried out on the quality aspect of the made teas from the bushes under sun and shade.

Leaf samples were collected at weekly intervals from the shaded and unshaded plots and 1 kg samples were manufactured following usual practices for evaluation of cup-characters. The experiment was continued for 3 years and the teas were tasted by Tocklai tasters. Details are presented in Table 1.

Table 1. Details of average yield and valuation of teas from shaded and unshaded plots (Average over 3 years)

Shade	Manure (kg/ha.) N	P	K	Average yield (kg/ha.)	Average valuation (Paise/kg)	Total out turn (Rs/ha.)
Full sun	112	—	-	937	601	5631.37
Under Odoratissima shade	112	—	-	1194	593	7080.42
Full sun	224	-	-	975	594	5791.50
Under Odoratissima shade	224	—	—	1242	578	7178.76
Full sun	224	45	90	1244	582	7240.08
Under Odoratissima shade	224	45	90	1405	574	8064.70

Results shows that there is a slight decrease in the value of tea when yield increases either due to manure or due to shade. It has also been reported earlier that reduction of light intensity to 50 per cent of full sun, either by mechanical shade or by tree shade did not produce any adverse effect on the teas. If anything, the overall character of the teas slightly improved in the lower light.

There should therefore be no apprehension that shade depresses quality and the belief in some quarters that quality of tea deteriorates under shade, is baseless. On the contrary, the total outturn per hectare in terms of money will be much higher from shaded plots than in the sun, which is evident from three years average data (Table 1).

Pruning and plucking

Dry matter content

The rate of dry matter production is one of the important factors associated with yield. Efforts were made to estimate the rate of increment of dry matter per unit leaf area by leaf disc method. Leaf discs were collected from both the lamina of a leaf in the morning. Later in the afternoon the discs were again collected from the same leaves. The increment in dry weight was estimated per unit leaf area in unit time. It may be possible to identify the yield potential of a clone or a jat by this method. However, other factors like number of shoots, regeneration of shoots etc. will also have to be taken into account.

The results from this investigation suggest that if a tea bush is plucked late during a day, the increment in dry matter will be substantially higher than plucking earlier in the day. In other words, the outturn of made tea from the same quantity of leaf will be significantly more if plucked at 1 p.m. than the leaf plucked at 8 a.m. in the morning.

The rate of increment, however, will vary depending upon environmental conditions, which is generally more significant in bright weather than in dull, overcast conditions. Further investigation is being continued.

Dormancy

The findings on the effect of day-length on winter dormancy have been reported earlier (Annual Scientific Report, 1968-'69, pp. 61-62; 1969-'70, pp. 44-45; Nature, 224:5218, 1969). Early bud break could be induced by application of gibberellic acid and also by increasing day-length for a period of two hours with weak artificial illumination in the early morning and late afternoon.

With the commissioning of the Growth Room, investigations were carried out on the effect of temperature on dormancy of tea. It was found that flushing could be induced in tea within two weeks during the short-day periods in winter months by subjecting the plants to higher temperature and humidity, creating similar conditions to the summer months. The conclusion to be derived from this experiment is that low temperature and humidity appears to be one of the factors for winter dormancy in tea in North-East Indian conditions.

Considerable progress was also made in the work involving bioassay of growth regulating substances which was briefly reported in the Annual Scientific Report, 1971-'72, p. 49. The study suggests that the balance between the growth promoting substances like gibberellic acid and growth retarding substances like abscisic acid in different periods of time is mainly responsible for growth and banjiness in tea. Variation in the hormonal balance from clone to clone was also observed during different seasons. Generally the level of growth promoting substances was highest during July/August, but gradually declined as the season advanced towards winter.

Entomology Department

Clonal susceptibilities to mites

Susceptibilities of the Tocklai clones TV 6 to TV10 to scarlet mite, *Brevipalpus phoenicis* (Geijskes) were assessed from the fecundity of the mite on these clones. At 25°C with 70-75% R.H., the mite laid maximum number of eggs on TV8 and TV 10 (Table 1). Oviposition was least on TV 7 and TV9, with TV 6 occupying an intermediate position. At a temperature of 30°C, more or less a similar trend was maintained though comparatively more eggs were laid on each of these clones. This suggests that the intrinsic ovipository response of the mite somewhat varies with temperature.

Inspite of the clonal variation in the oviposition response of the mite, the duration of its life cycle remains fairly steady on all clones. Clearly, by virtue of its high fecundity alone, the mite can initiate a high population build up on some clones.

The factors that regulate the varying oviposition of the mite on the clones are not immediately clear. However, subtle difference in the composition of the leaves from different clones could be consequential.

Table 1. Fecundity and the life cycle of *Brevipalpus phoenicis* (Geijskes) on some Tocklai clones.

Clones	25°C		30°C	
	Average No. of eggs laid	Duration of life cycle	Average No. of eggs laid	Duration of life cycle
TV 6	7	30	16	24
TV 7	4	29	10	24
TV 8	11	28	18	25
TV 9	4	30	5	25
TV 10	15	29	17	25

Sampling of the field populations of red spider on China clones 317/1, 317/2, 317/3, 317/4, 317/5, 317/6, 317/7 and 317/8, all under comparable conditions, indicates that at any time of the year mite population remains comparatively high (average 4.57/leaf) on clone 317/5 and 317/7. This contrasts sharply with the steady low population (average 1.05/leaf) on 317/1 and 317/6, with rest of the clones occupying an intermediate position. These observations cannot be generalized at present; long term studies on the population cycle of the mites on these clones are continued.

Distribution, abundance and succession of pests in relation to field management practices

a) **Red spider population in relation to pruning/skiffing**

Comparative studies on the population cycle of red spider on mature Assam Teas under differential pruning were initiated. The pruning operations include unprune, top prune, light skiff, medium skiff and deep skiff. Throughout the year unpruned and light skiffed teas had more mites than comparable teas under other forms of skiffing/pruning. Relative abundance of the mites on these teas is possibly linked to the availability of the leaves under different forms of pruning/skiffing, though the role of other related factors cannot be ruled out.

b) **Red spider infestation, yield and acaricidal treatment**

Direct estimations of the potential yield loss due to red spider, and the effect of spraying on yield and mite population cycle were made.

A plot of 150 Assam bushes was sprayed with Kelthane 18.5 E.C. at 0.23% concentration in May 1974, with a comparable plot remaining unsprayed. Starting one week after spraying yields from these two plots were recorded every week, till end October. Pooled data (Fig. 1) show a steady increase in yield in the acaricidal treated plot, resulting in a cumulative 13.5% increase in crop at the end of the observation period.

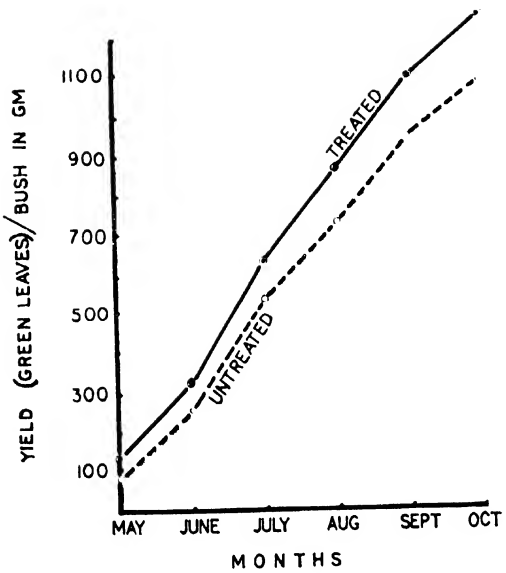


Fig. 1. Yield of tea from Kelthane treated and untreated plots

It was worthnoting that the acaricide was applied only once during the experiment, but this kept the mites under control continuously for 12 weeks (Fig. 2). From July population in the treated plot started increasing, but took a downward trend in September. In the untreated plot an inexplicable population decline (Fig. 2) in June was followed by a sharp rise in July, eventually staying at a low level during August and September. The contrast in the population cycle of the mite on treated and untreated plots was clear.

Biology of cockchafer

Bionomics of the two species of cockchafer, *Sophrops plagiatula* (Brenske) and *Sophrops iridipennis* (Brenske) in the North Bank was continued. The additional newly recorded species from North Bank include *Anomala perplexa* (Hope), *Anomala bilobata* Arrow and *Adoretus versutus* Har. We are not certain as yet about the extent of damage by these newly recorded species but observations continue.

The seasonal cycles of *S. plagiatula* and *S. irridipennis* are very similar to that of *Phyllophaga seticollis* in the Dooars reported earlier.

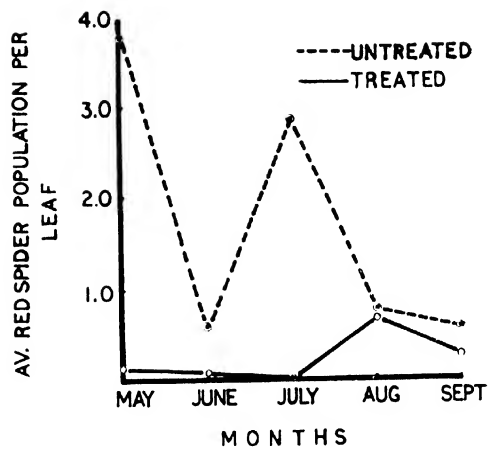


Fig. 2. Population cycle of red spider on Kelthane treated and untreated plots

The diapausing adults become active and emerge during March to May, but unlike *Phyllophaga* they do not settle either on *Albizzia chinensis* or on *Indigofera teysmanii*.

Adults lay approximately 40 eggs during the oviposition period of 15 days. Fecundity rate remains nearly uniform. Eggs hatch into the first instar in about 10-12 days time during March to May. First instar grubs feed on dry tea leaves, tender roots of grasses etc but not on the bark of young clones.

In about 4 to 5 weeks time the first instars develop into the second instars which shift its preference for food from leaf litter to live bark of young clonal tea.

In the field both first and the second instar grubs are attracted by mulch or any other decomposing vegetation. A survey shows on an average four grubs are present in 0.09 sq. metre (one Sq. ft.) of mulched area as against 1.5 grubs in the comparable unmulched areas.

Biology of root knot nematodes

Amongst the plant parasitic nematodes infesting tea in the nursery, root knot nematodes (*Meloidogyne incognita, M. javanica* and *M. hapla*) and root lesion nematode (*Pratylenchus brachyurus*) are common. Of

these, *M. incognita* is the most important. Studies on certain aspects of its biology were made.

Effect of soil pH on root knot infestation : A pot trial was carried out with soils having pH levels 4.0, 4.5, 5.0 and 5.5 inoculated with populations of *M. incognita* all at the same level. Tea seedlings were grown in these pots for 75 days, when the plants were uprooted and scored for the degree of infestation in the roots. *Meloidogyne incognita* infestibility (Table 2) was higher in more acidic soils.

Table 2. Effect of soil pH on infestation by the root knot *Meloidogyne incognita*

Soil pH	Average degree of infestation
4.0	2.62
4.5	1.44
5.0	1.0
5.5	1.0

Effect of soil types on root-knot infestation : A pot trial with sandy loam, loam and silty loam soils with initial *Meloidogyne* populations at the same level suggests that the degree of infestation is slightly more in sandy loam soil. Further experiments to confirm this finding are in progress.

Effect of temperature on hatching of *Meloidogyne incognita* eggs : To study the hatchability of the eggs of *M. incognita* at various temperatures, equal numbers of egg masses were kept at 20°, 25°, 30°, 35°, 37.5° and 40°C. Hatching was maximum at 30°C; only a few hatched at 37.5°C and none at 40°C which therefore is the thermal death point for *Meloidogyne* eggs.

Comparative efficiency of nematode extraction methods : A series of extractions were carried out, processing the soil sample with known nematode populations, by four different methods, (1) Baerman technique (2) Oostenbrink-Baerman technique (3) Sieving technique and (4) Floation technique. Extraction efficiency (Table 3) of the techniques was in the order of Floatation>Sieving> Oostenbrink-Baerman > Baerman. The efficiency was assessed on the basis of nematode numbers extracted in unit time.

Table 3. Extraction efficiencies of different methods in nematode isolation

Methods of extraction	Percentage nematode population extracted in 24 hours
Floatation	80
Sieving	72
Oostenbrink- Baerman	60
Baerman	10

Morever, a series of extraction trials by floatation technique show (Fig. 3) that about 85% of the extractable nematode population from a soil sample can be isolated only within 3 hours after processing the soil sample.

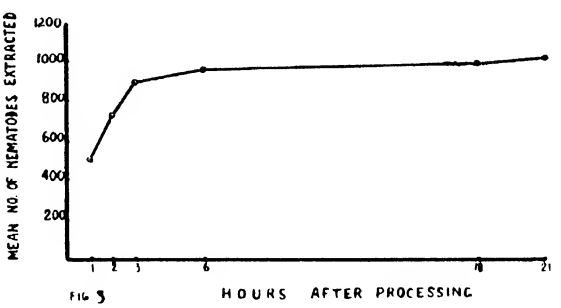


Fig. 3 Average numbers of *Meloidogyne incognita* Chitwood extracted at different hours by Floatation technique

Nematode Survey in Darjeeling : A nematological survey on the distribution and abundance of various plant parasitic nematodes was conducted in Darjeeling. Major nematode pests of tea are concentrated at altitudes varying between 270 and 1800 m (900—6000 ft.)

Screening and evaluation of pesticides Economy in acaricide use

Toxicities of Nuvacron 40 E.C. and Zolone 35 EC against red spider @ 1.25, 1.00, 0.75, and 0.5 litre/hectare were compared with that of Tedion 8% EC at 1.25 litre/hectare which is the standard recommendation.

Even 4 weeks after spraying performance of Tedion was by far the best (Table 4), though the performance of Nuvacron at 1.25 and 1.00 litre/hectare was close to it. At 0.75 and 0.50 litre/ha Nuvacron was moderate, but Zolone was least effective.

Table 4. Effect of lower concentration of some acaricides on the cumulative mortality of red spider

Rate Litre/ha	Number of red spider alive per 100 leaves on the fourth week after spraying							
	Nuvacron		Zolone		Tedion		Control	
	Mean	% reduction	Mean	% reduction	Mean	%reduction	Mean	%reduction
1.25	18	96	43	90	4	99	439	—
1.00	31	93	151	66	—	—	-	-
0.75	95	78	230	48	—	—	-	-
0.50	129	71	256	42	-	-	—	—
Least significant difference at P = 0.05	124	-	—	—	-	—	—	-
C. V. %	52							

Omite 57 E and Acarthane 27 EC each @ 1.25, 1.00 and 0.75 litres/hectare against red spider were equitoxic. In all cases cumulative mortality of red spider four weeks after a round of spraying stood at 90 per cent level. It is possible that at lower doses these acaricides could be toxic to low populations of red spiders.

Insecticides

Looper caterpillars : Nuvacron 40 EC, Phosvel 34 EC, Dursban 200 EC and three formulations of Endosulfan 35% EC were sprayed @ 1.25 litre/hectare against mixed populations of different instars of looper caterpillars (*Biston suppressaria* Guen). All were nearly equitoxic, though with Nuvacron, Asafan and Endosulfan a slightly higher mortality was obtained (Table 5).

Table 5. Mortality response of looper caterpillars to some insecticides @ 1.25 litre/hectare

Insecticides	No. of living population of looper after one week and percentage reduction over control (Mean of 3 replications)	
	Mean	% reduction
Asafan	1	96
Starsulfan	3	89
Phosvel	7	71
Nuvacron	1	96
Endosulfan	2	94
Dursban	5	80
Control	25	—
Least significant difference at P = 0.05	4.42	
C.V. %	47.38	

Scale insects in Darjeeling : Elsan 50 EC, Phosvel 34 EC and Zolone 35 EC when sprayed in August each at 1.25 and 1.00 litre to a hectare gave satisfactory control of *Ceroplastes* sp. But Dursban was effective only at 1.25 litre to a hectare, suggesting that the mortality response of the scale may vary with the nature of the insecticides.

Termites : Dursban 200 EC, Elsan 50 EC, Nuvacron 40 EC, Phosvel 34 EC and Thiodan 35 EC were sprayed at the rate of 10 and 5 litres per hectare. Only at 10 litre/hectare, did the insecticides keep the termites under control for about a year. None of the insecticides was effective at the lower rate, suggesting a strong concentration of insecticide is essential for long term control of termites.

Nematocides

DBCP (40 litre/hectare), Temik 10 G and Thimet 10 G (each at 180 kg/hectare) were applied to the soil with an injector gun against root-knot nematodes (*Meloidogyne* spp.). Only Thimet 10 G did keep the root knot population under control for about 10 months: others failed to do so.

Sprayers

Performance of a new sprayer, Ulva Micron (a new battery operated sprayer), was compared with that of conventional mist blower using Ethion 50 EC at 1:80, 1:150, 1:300 and 1:500 against pink mite (*Acaphylla theae* Keifer (Watt). Performance with Ulva Micron at all concentrations of the acaricide was slightly on the lower side compared to that of the conventional mist blower (Table 6). In both cases, high mite mortality was obtained at 1:80 concentration of Ethion 50 EC.

Table 6. Comparative efficacy of two types of sprayers in controlling Pink mite *Acaphylla theae*

	Number of live pink mite per 15 leaves on the fourth week after spraying							
	1 : 80		1 : 150		1 : 300		1 : 500	
	Mean population	% reduction	Mean population	% reduction	Mean population	% reduction	Mean population	% reduction
Mist blower	16	90	32	79	46	70	69	55
Ulva Mi-rocron	27	82	38	75	60	61	85	45
Control (No spray)	154	- -	154	—	154	- -	154	- -
Least significant difference at P = 0.05 = 37.21								
C. V. % = 12.23								

Tainting effect

Tainting trials were conducted with X-factor, Thimet 10 G, Ekalux 25 EC, Dimecron 100 E, Stardifon 8 EC, Stethion 50 EC and Starkel 18.5 EC. According to Tocklai Tea Taster, none except X-factor, did impart any taint to made tea.

Pesticide residue tolerance

On the basis of our work and recommended rate of application, Environmental Protection Agency (EPA) of the United States granted a tolerance level of 8 ppm to Zolone 35 EC on made tea.

Samples of black tea, manufactured from Acarthane 27 EC and Omite 57 E treated plots are being processed for residue analysis.

Pesticide Certification

34 certificates of approval were issued to various formulations of plant protection chemicals. 18 certificates were revalidated after bioassay studies. Agreements were made for formal testing of 28 formulations of various pesticides.

Scale insect biology

The black scale, *Chrysomphalus ficus* Ashmead (Fig. 4), is a new record from tea. It damages young tea and V.P. cuttings and in extreme cases about 70% of the plants may be infested in the Dooars and Assam Valley.

Fig. 4 Leaf showing unfestation of Black scale, *Chrysomphalus, ficus*

In the laboratory the eggs incubate for 1-2 days in summer against 2-5 days in winter. Female undergoes two, and the male four moults, before becoming adults. Total duration of the female instars is 23 days in summer and 63 days in winter: corresponding period for male instars are 30 and

75 days respectively. The relatively quicker development of the female coupled with high fecundity (160 eggs during life time) is conducive to the rapid establishment of the scale on young plants.

A marked altitudinal difference exists in the distribution of scale insects in Darjeeling. *Phenacaspis manni* (Green) and *Eriochiton theae* (Green) are restricted between 1050 and 1800 m (3,500 - 6000 feet), but *Pinnaspis theae* (Maskell) is distributed mostly at lower elevations, between 600 and 1050 m (2,000-3500 feet). Biology of these scales is likely to reflect this differences in their spatial distribution. This aspect is now being studied.

An armoured scale (*Andaspis dasi* Williams) has been recorded for the first time to attack china and china hybrid teas in Darjeeling.

Integrated Control

Fortnightly observations on the seasonal abundance of the predators of the red spider were continued. In July average population of the Coccinellid predator *Stethorus gilvifrons* Mols. was 5.00 per ten leaves. The low mite population in the following two months was possibly due to the confounded effect of the activity of this predator and a natural decline in the intrinsic rate of multiplication of the mite.

Field populations of the black scale, *Chrysomphalus ficus* Ashmead, were parasitized by the encyrids (Hymenoptera) *Comperiella bifasciata* Howard and *Microterys* sp. Both are first records from tea, and between them they parasitized between 28% and 67% of the field population of the scale insect. Attempts are now being made to develop a spraying schedule that will utilize the activities of these predators.

MISCELLANEOUS

Visits : Training

Dr. B. Banerjee, Head, Department of Entomology, was attached to the University of Nairobi for a year under a IDA World Bank Project, as the Visiting Professor in Agricultural Entomology and Adviser in Pest Management. Dr. Banerjee chaired the session on "Pest Management" at the EACEF Entomological Congress. He also visited several international research organization. Mr. N. Sengupta, Assistant Entomologist, was in charge of the department during his absence. Mr. M. C. Borthakur went for a three months advanced training in plant protection technique at the Central Plant Protection Training Institute, Hyderabad.

V.P. trainees and newly recruited Junior Scientific Assistants from Advisory Department were given refreshers course in Pest control technology.

Advisory work

Pest infested materials from member esates were examined and remedial measures suggested. 4,000 soil samples were analysed for eelworm populations. Bioassays were made for the samples of pesticides received from estates.

Mycology Department

Biology and control of diseases

Red rust :

(*a*) Work during the year was mainly on the chemotherapeutic control of the disease.

Two experiments were laid to study the efficacies of different chemical formulations compared to that of standard copper oxychloride (Blitox).

(*b*) Biology and epidemiology of the causal organism *Cephaleuros parasiticus* could not be studied as Hirst-Spore Trap was not functioning,

(*c*) Possibility of the use of reduced quantity of fungicide on red rust control was investigated.

Alternate fungicides for economic control of red rust

Trial No. 1 : Two trials--one in Moran circle and the other in Golaghat circle were laid out to find out alternate fungicide for economic control of red rust. Young clonal tea was sprayed at different time interval, the first two rounds at fortnightly interval, and the next two at monthly interval. Each plot had 50 bushes and treatments were replicated 5 times. The degree of red rust incidence on a scoring of 0-4 (details of scoring reported in the Annual Scientific Report, 1973-74, p. 53), as influenced by different chemical spray for trial in Moran circle is presented in Table 1.

Trial No. 2 : In this trial two fungicides, viz., TOC 156 and TOC 157, was replaced by Blitox at 1 in 1000 parts of water with and without Triton AE, other fungicides being same as in Trial No.1. The results are also incorporated in Table 1 along with the results of trial No. 1.

Table 1. Average red rust incidence (over 5 replications) following various fungicidal treatments with different doses

Sl. No.	Treatment	Approx. dose (kg/ha)		Dilution	Disease incidence	
		Trial I	Trial II		Trial I	Trial II
1.	Blitox + Triton AE	1.5	2.5	1 : 400	0.24	0.16
2.	Blitox	1.5	2.5	1 : 400	0.50	0.22
3.	TOC 156	1.5	—	1 : 400	1.12	-
4.	TOC 157	1.5	-	1 : 400	1.28	-
5.	Difolatan	1.5	2.5	1 : 400	1.80	0.52
6.	Cetyl trimethyl ammonium chloride	.009	.015	1 : 66666	2.04	1.75
7.	Dithane M-45	1.5	2.5	1 : 400	2.32	1.49
8.	Blitox + Triton AE	-	1.0	1 : 1000	-	0.60
9.	Blitox	-	1.0	1 : 1000	-	0.57
10.	Control	-	-	-		1.83
	C.D. at 5%				0.49	0.24
	C.V. (%)				25.27	20.48

Amount of fungicide used normally depends upon the spread and size of the bush. The bushes in trial No. 2 were much bigger in size than those in Trial No. 1. For this reason, about 1000 litres of water/ha was required in Trial No. 2 as against 600 litres in Trial No. 1. Therefore, it is better to specify the dilution and spray to efficiently cover the area, which may approximately be the quantity of fungicide stated above.

In these two trials, Blitox at 1:400 concentration gave the best control (Trial 1). Use of Triton AE improved its efficacy. With lower dosages, the effect of Triton AE was not as evident as in the higher concentrations and no explanation was possible at this stage on its beneficial action or otherwise in disease control.

Performance of TOC 156 and 157 was, however, encouraging whereas Cetyl trimethyl ammonium chloride and Dithane M-45 were not promising.

Blitox at 1:1000 gave significant reduction in disease incidence, but not in the level as obtained at 1:400 (Table 1).

Application of lower doses of fungicides calls for an *extremely* high grade supervision without which the desired results connot be achieved. *Thorough* drenching of the frames and leaves is a must by hand operated sprayers.

An elaborate experiment is being laid out, including different lower doses of fungicide applied fortnightly for six rounds, to decide upon the optimum dose of fungicide.

Difolatan is an organic chlorinated hydrocarbon. Clarification about its use on tea under plucking is sought from the EPA.

Branch canker

Pancil 'T' (Indofil) and PP 395 (ICI) are being studied for the control of *Poria* in plains and *Aglaospora* in Darjeeling.

Black rot

Control measures of Black rot : Seven formulations, including Blitox, were sprayed on the black rot affected bushes in a tea estate in North Bank. The tea was planted during 1959-61. Two rounds of spraying were done and results observed on two occasions over 4 replications each consisting of 40 plants. The results presented in Table 2 show the degree of incidence on a scoring of 0-4 following chemotherapeutic treatments.

Table 2. Average black rot incidence following various chemotherapeutic treatments

Sl No.	Treatment	Degree of incidence (Average of 160 plants)
1.	Blitox 1 : 400 + Triton * AE	0.37
2.	Difolatan 1 :400	0.52
3.	Blitox 1: 400	0.55
4.	TOC 156 1: 400	0.74
5.	TOC 157 1 : 400	0.82
6.	Bavistin 1 :1000	1.09
7.	Dithane M-45 1 :400	1.33
8.	Control – unsprayed	2.29
	C.D. at 5%	0.45
	C.V. (%)	31.6

* Triton AE @ 60 ml/100 l of spray fluid

Table 2 shows that amongst the alternate fungicides studied, Difolatan, TOC 156 and TOC 157, in addition to copper fungicides, gave best control of black rot. Bavistin (BASF), claimed to be a systemic fungicide, failed to give an adequate reduction as copper fungicides did, though it reduced incidence significantly as compared to that of unsprayed controls.

However, all the formulations tried, gave a significant reduction in the disease incidence. Blitox at 1: 400 with or without Triton AE proved to be the best of all the formulations tried.

In a single plot trial, 40 black rot affected plants were sprayed with copper fungicide at 625 g/ha in two rounds and the resultant trend was encouraging (Table 3).

Table 3. Effect of reduced dosage of copper fungicide on black rot incidence

Sl. No.	Treatment	Degree of incidence
1.	Unsprayed control	2.30
2.	Copper 1 : 400	0.55
3.	Copper 1 : 1600	0.87

Detailed study in this direction is being continued.

Primary root rots

Soil Fumigation was initiated to control the primary root rot diseases of tea, i.e., Charcoal stump rot caused by *Ustulina zonata* (Lev.) Sacc., and Brown root rot by *Fomes lamaoensis* (Murr.) Sacc. and Trott. The first experiment was laid out in 1973. Four more experiments were laid out in subsequent years in estates located in South Bank, North Bank and Darjeeling.

The following soil fumigants are under study at dosages indicated:

1. Vapam (Indofil) applied at 8 ml/hole of 25—30 cm deep dug at every 30 cm
2. Telone (Dow) -do- -do-
3. Dichloroethane (NOCIL) -do-
4. Calixin 0.75 litres/ha
5. Bavistin at 1 kg/ha as solution
6. Lithium chloride 1 gm/sq. ft. (sq. 30 cm)

Fumigation was done to the extent of two rows of apparently healthy bushes after uprooting *only the dead bushes*. Replanting was done during the 10th - 12th week after the fumigation. One of the experiments has been under observation for two years but no mortalities have been recorded so far. Observations will continue for another season prior to issuing recommendation.

Blister blight

Investigation on the control of Blister blight continued in Darjeeling during 1974-75 to confirm the effect of alternate fungicides and find out the possibilities of using lower doses of copper fungicides.

There were 12 treatments (Table 4) with seven chemical formulations. The treatments were replicated 4 times and the blister count was taken on 400 shoots collected at random from the pluckings.

The top hamper was given 4 rounds of weekly spray and the final observation was taken a week after the last round. Mist blowers were used in spraying except in treatment with copper oxychloride at 1:800 concentration where a hand operated sprayer was used.

Shoots were plucked for observation prior to the spraying each week and these were examined for blister count record within the next 24 hours.

Table 4. Effect of Chemotherapeutants in the control of Blister (Observation taken on 10.9.74)

Sl. No.	Treatment	Rate	% shoots infected (Av. 400 shoots)	% reduction over control
1.	Difolatan	2.5 kg/ha	6.75	85.32
2.	Dithane M-45	2.5 kg/ha	6.75	85.32
3.	TOC 156	2.5 kg/ha	5.50	88.04
4.	TOC 157	2.5 kg/ha	6.75	85.32
5.	Sicarol 50 W.P.	300 g/ha	4.25	90.76
6.	Nickel chloride	500 g/ha	14.00	69.57
7.	-do-	1.25 kg/ha	7.75	83.15
8.	Blitox	1.25 kg/ha	4.25	90.76
9.	Blitox	0.625 kg/ha	10.50	77.17
10.	Blitox with Triton AE	0.625 kg/ha 500 ml/ha	11.00	76.01
11.	Blitox	1 : 800	6.75	85.32
12.	Unsprayed control	- -	46.00	—
	C.D. at 5%		3.87	
	C.V. (%)		24.76	

Nickel chloride is not recommended for spray as it is not cleared by EPA for use on food and fodder crops.

The position of Difolatan is still not clear. It is a organic chlorinated hydrocarbon.

The formulations studied have recorded a significant reduction in the disease incidence as compared to that of unsprayed treatments.

Use of hand sprayer : After getting efficient control by using 0.625 kg of fungicide/ha with power sprayers in the previous year, it was thought necessary to test the efficacy of the same quantity of fungicide applied with a hand sprayer. It is known that for the top coverage, as is required for blister blight control, spray fluid around 500 litres are required for one hectare. Therefore to have 0.625 kg of fungicide in 500 litres, 1 part in 800 parts of water is required and this as is evident from the table has given very good control of the disease.

Miscellaneous

TV 18 clonal plants, which were growing vigorously, developed leaf scorch of an unknown origin and gradually the leaves dropped off. It spread from the middle portion of the bush to the bottom and top leaves and the attacked plants succumbed to the infection.

Control of the disease by fungicides both organic and inorganic was not encouraging. Streptomycin sulphate at a rate of 5 gm in 5 litres of water when sprayed with a hand operated sprayer reduced disease symptoms and the further deaths were prevented in 1973-74.

No fungal organism was recovered from both platings as well as washing of the leaves. Macerated tissues yielded two bacterial starins from the infected leaves which appear identical to genus *Pseudomonas*. These are under study for pathogenicity and systematic diagnosis.

RESEARCH AND EXPERIMENT

Biochemical differentiation of clones

In continuation of our project on biochemical differentiation of clones based on green leaf analyses, TV 19 and TV 20 were analysed for enzyme activity ($Q0_2$, μl/mg/hour), total oxidisable polyphenols expressed as total oxygen uptake (μl/mg/2 hours), chlorophylls and amino acids of fresh leaf and theaflavins (TF) and thearubigins (TR) for corresponding black teas.

The analytical data (Table 1) indicate higher enzyme activity and lower oxygen uptakes for clone TV 20 than those for TV 19 but there was no appreciable difference in theaflavins and thearubigins contents of the corresponding teas of those clones. This means that eventhough clone TV 20 contains more active polyphenol oxidase, it does not have proportionately high total oxidisable polyphenols to produce higher content of TF during manufacture to enhance the quality of tea. In other words, these results indicate that biochemically both the clones are of similar quality. The average valuation given by tasters were practically the same for teas of both the clones, which corroborates the biochemical observations.

Table 1. Enzyme activity and total oxygen uptakes of green leaf and TF and TR of the corresponding made teas. Figures expresed are the averages of 23 repeats

Source of leaf	Freshly plucked shoots		Made teas		
	Enzyme activity μl/mg/hour	Total oxygen uptakes μl/mg/ 2 hours	TF (%)	TR (%)	TF/TR
TV 19	13.36 ± 0.342	11.10 ± 0.133	1.67	14.99	.113
TV 20	15.11 ± 0.462	9.10 ± 0.179	1.63	15.97	.103

MANAGEMENT PRACTICES

Pruning Experiment

To study the biochemical aspects of the quality of the tea shoots under different management practices, shoots were collected from the pruned and unpruned bushes of clone TV1 and TV18 and were analysed for enzyme activity, total oxygen uptakes, polyphenols [(—)- epigallocatechin (EGC), (—) - epicatechingallate (ECG), ( ) epigallocatechin gallate (EGCG) and theogallin (TG)], major amino acids and chlorophylls of green tea shoots and TF and TR of the made teas.

Polyphenols and Enzymes

Results (Table 2) show that there is no sharp difference in the enzyme activity, total oxygen uptakes of leaves and TF and TR of the corresponding teas, but there is always a tendency to show higher enzyme activity and total oxygen uptakes in the unpruned shoots than those of the pruned tea, except that pruned shoots from TV 18 show slightly higher enzyme activity. Similarly, TF and TR contents are always higher in the unpruned than the corresponding pruned tea except for TV1 in which case pruned teas show higher TF than the unpruned teas. Polyphenolic contents in TV1 are the same for both pruned and unpruned bushes, but are higher in unpruned of TV 18 than the pruned TV18.

Table 2. Enzyme activity, total oxygen uptakes and polyphenols of green leaf and TF and TR of made teas

Sources	Leaf			Tea		
	Enzyme activity $Q0_2$/ μl/mg/hr	Total oxygen uptakes μl/mg/2 hrs.	Total polyphenols (EGC+ECG+EGCGD)(%)	TF (%)	TR (%)	Ratio TF/TR
TV 1 (Pruned)	13.64 ± 0.250	10.93 ± 0.107	12.5256	1.57	17.49	.091
TV 1 (Unpruned)	14.14 ± 0.339	11.36 ± 0.235	12.5956	1.33	18.28	.073
TV 18 (Pruned)	13.71 ± 0.318	8.43 ± 0.080	13.9871	1.32	13.71	.096
TV 18 (Unpruned)	12.42 ± 0.284	9.33 ± 0.125	15.5695	1.43	14.66	.099

Chlorophylls

Both chlorophylls 'a' and 'b' are higher in the tea shoots of the pruned bushes than the corresponding unpruned sources (Table 3) throughout the entire plucking season.

Table 3. Chlorophylls (%) of the tea shoots of pruned and unpruned bushes (Average of 23 observations throughout the year)

Components	Clone TV 1		Clone TV 18	
	Unpruned shoots	Pruned shoots	Unpruned shoots	Pruned shoots
Chlorophylls 'a'	2.12	2.42	2.60	2.91
Chlorophylls 'b'	1.49	1.69	1.66	2.00
Chlorophylls a + b	3.61	4.11	4.26	4.91

Amino Acids :

Our earlier observation on amino acids vs tea quality is that major amino acid contents (aspartic acid, glutamic acid, glutamine, theanine etc.) were negatively correlated with quality (Tocklai Annual Reports, 1972-73, 1973-74). Another observation showed that amino acids, in general, were highest in the early first flush, lowest in the second flush and high again in the autumn (Tocklai Annual Report, 1972-73). Our present work aims at amino acids contents in tea under different agro-management practices. Leaves from the pruned and unpruned bushes of clones TV 1 and TV 18 were examined for amino acids throughout the plucking season and these teas were tasted by the Tocklai Tasters. From the analyses (Table 4) we may conclude that in general, a sum total of aspartic acid, glutamic acid, serine, alanine, glutamine, tyrosine, leucines, valine and theanine is higher in the pruned than in unpruned tea. The quantities of aspartic acid, glutamic acid, serine and theanine were also higher in the leaves of pruned tea of each clones. In the light of our earlier findings that amino acids are negatively correlated with quality, we may conclude that teas from unpruned bushes are better in the cup than the teas from the pruned ones. Similar trend. though not very significant has been observed by the tea tasters (Table 5)

Table 4. Concentrations of major amino acids components in tea shoots plucked from unpruned and pruned bushes. Each figure (Mg/100 g dried shoots) in the average of 25 estimations undertaken during the period from May to November 1974.

Components	Clone TV 1		Clone TV 18	
	Shoots of unpruned bushes	Shoots of pruned bushes	Shoots of unpruned bushes	Shoots of pruned bushes
Aspartic acid	44.7	48.7	74.3	111.6
Glutamic acid	172.6	207.2	312.3	443.4
Serine	17.7	19.7	27.2	34.3
Glutamine	26.7	60.7	27.4	70.2
Alanine	33.7	38.5	43.6	52.7
Tyrosine	9.0	8.6	10.6	12.5
Leucines and isoleucines	19.4	20.0	20.8	23.9
Valine	13.0	12.5	15.0	21.7
Theanine	471.5	708.9	675.1	1250.8

Table 5. Correlation of taster's findings on made teas with amino acids contents of green leaves (average of 25 repeats)

Source of leaf	Amino acids mg/100 g dried leaf	Tasters valuation Rs./kg teas
Clone TV 1, pruned leaf	1124.8	6.77
Clone TV1, unpruned leaf	811.3	6.87
Clone TV 18, pruned leaf	2021.1	6.30
Clone TV 18, unpruned leaf	1206.3	6.48

High content of amino acids in the teas from pruned bushes is due to the fact that a part of the amino acids and carbohydrates are reserved in the roots. It is already known that amino acid, are higher in the roots than the green leaves (T. Takeo *Phytochemistry*, 1974, **13,** p. 1401). In pruned bushes metabolic processes are slow during winter, as a result translocation of these materials from roots to the growing regions is very slow. As soon as new shoots start appearing translocations of amino acids is rapid resulting in the higher content of amino acids in the pruned bushes than the unpruned ones. In the latter translocation of the chemical constituents is an uniform process.

Pigment Profile

An interesting and comprehensive result on pigment profiles of black tea was achieved last year at the Sheffield University by one of our staff. This observation, if further developed, may successfully be utilized for distinguishing the flushes, differentiating the clones on the basis of quality and finally chemical evaluation of tea quality as a complementary tool to commercial tasting rather than depending on the tea tasters alone. With this object in view, a prototype unit (as applied in the Sheffield University) has been set up locally instead of sending every samples of tea to U.K. as were done in the past; the work is in progress with encouraging results.

Study of Darjeeling Teas

A preliminary study of some of the chemical components of Darjeeling green leaves (dried) and the corresponding made teas were made during the year. In general, the moisture contents of dried green leaves and made teas were very high. Of other components, the tannin contents in green leaf and made teas were found to be less than those of the North East Indian plains green leaf and black teas; but total soluble nitrogen and amino acid nitrogen (in dried green leaf and made teas) were higher than those of N.E.I. Plain teas, TF & TR values of Darjeeling teas (Orthodox method of manufacture) are comparable with the poor orthodox variety of N.E. Indian plains teas. Curiously enough, the Darjeeling teas are poorer in respect of colour and strength than the orthodox teas of N.E. Indian plain teas. The study of the enzyme make up of the leaves in the Darjeeling area may give a better understanding of the colour and strength of those teas.

Table 6. Some of the chemical constituents of fresh leaf (dried) from Darjeeling area

	T 78	T 135	T 348	B 157
% Moisture	11.51 ± .274	11.71 ± .199	11.79 ± 0.317	11.60 ± .135
% Sol. Solid	44.61 ± .787	44.70 ± .937	39.34 ± 1.086	43.48 ± 1.174
%Tannin (Lowenthal method)	15.86 ± .572	16.10 ± .953	12.19 ± 0.779	16.09 ± 0.621
%Caffeine	4.02 ± .210	4.08 ± .238	3.69 ± 0.233	3.65 ± 0.223
%Total Sol nitrogen	2.17 ± .322	2.20 ± .357	2.26 ± 0.283	2.0 ± 0.406
% Amino acid nitrogen	1.01 ± .329	1.02 ± 0.348	1.19 ± 0.278	0.99 ± 0.420

Table 7. Some of the chemical constituents of orthodox teas from the Darjeeling area.

	T78	T135	T348	B 157
% Mositure	10.92 ± .500	11.17 ± 0.274	11.04 ± 0.534	10.78 ± .359
%Sol. Solid	41.42 ± .642	40.57 ± 1.419	36.53 ± 1.436	40.57 ± .455
% TF	0.66 ± .122	0.63 ± 0.000	0.43 ± 0.000	0.49 ± .000
%TR	8.91 ± .796	8.88 ± 0.765	8.08 ± 0.374	8.27 ± .472
% Tannin	14.44 ± .000	13.68 ± 0.942	10.09 ± 1.418	12.87 ± .287
% Caffeine	3.90 ± .200	4.07 ± 0.158	3.77 ± 0.239	4.21 ± .249
% Total Sol. nitrogen	1.92 ± .097	1.92 ± 0.147	1.83 ± 0.163	1.98 ± .118
% Amino acid nitrogen	0.76 ± .054	0.74 ± 0.115	0.75 ± 0.095	0.76 ± .047

Analysis of Samples

One hundred thirty one samples from Research Engineering & Development Department and Tea Tasting Department and forty three samples from various tea estates were analysed for theaflavins and thearubigins and moisture contents respectively.

Moisture Meters

Two Infra-Red moisture meters (Kaybee) from different tea gardens were calibrated during the year.

Tea Tasting Department

Tainting of teas due to use of different commercial products both in field and factory

Plywood tea chests bonded with a new adhesive formulation, received from the Indian Plywood Industries Research Institute, Bangalore were tested to find out if the new adhesive, which was more economical than formaldehyde resin, could be used on plywood for bonding without tainting the made teas or causing any other deleterious effect when packed. These were compared with normal tea chests from a commercial factory complete with tissue paper, aluminium foils and fittings.

Fresh made teas from the same bulk were packed in three normal chests and in three plywood chests bonded with a new formulation to evaluate taint, moisture content and chemical deterioration of the teas, if any, after storage for 1 month, 3 months and 6 months. Samples of tea from these chests were sent to tasters at Calcutta, London and Tocklai for tasting and to the Biochemist for determination of theaflavin, thearubigin and moisture content. Taster's evaluation and biochemical estimations are shown in tables 1 and 2 respectively. Calcutta panel of tasters reports were negative in all respects, hence their remarks can be ignored.

Table 1. Taster's evaluation of tea packed in chests of different materials

Taster	Tocklai			London		
Date	Valuation		Remarks	Valuation		Remarks
	IPIRI Chest	Control Chest		IPIRI Chest	Control Chest	
1	2	3	4	5	6	7
27.12.73	4/80	5/-	No			
24.1.74	4/80	5/-	No	4	5.5	Very little to choose from any of these samples
25.3.74	4/80	5/-	No	5.5	5	No remarks
24.6.74	6/27	6/27	No	4	4	Nothing 'foreign'

Table 2. Moisture and chemical estimations of tea packed in chests of different materials

Characters	Moisture (%)		TF (%)		TR (%)	
Chest / Date	IPIRI Chest	Control Chest	IPIRI Chest	Control Chest	IPIRI Chest	Control Chest
Initial	5.22	5.18	1.62	1.75	17.51	18.71
24.1.74	5.92	5.50	1.62	1.63	16.94	16.91
25.3.74	7.01	7.95	0.34	0.34	6.51	6.42
24.6.74	6.99	6.66	1.66	1.39	15.95	17.65

The results shown in tables 1 and 2, suggest that IPIRI Experimental chests are as good as normal tea chests manufactured with ISI specified adhesive glues, for packing and storing teas.

Packaging and Storage

Experiments using the following packaging materials were carried out during the season to test the suitability of them for packing made tea.

(i) Polycoated Hessian bag, Polylaminated Hessian bag and Polylaminated Bitumen Hessian bag.

(ii) Plasticoated White paper and Plasticoated Glassine paper linings.

These samples were received from the Secretary, Indian Tea Association, 6, Netaji Subhas Road,

Calcutta-1 and Messrs Guardian Plasticote Ltd., 12, Ho Chi Minh Sarani, Calcutta.

Fresh teas from the same bulk packed in each experimental bags and those in plywood chests were opened after a period of 1 month, 2 months and 3 months intervals to test for taint, moisture and chemical analysis of teas. Similarly teas packed in bags made of Plasticoated White paper, Plasticoated Glassine paper and normal plywood chests were opened in same manner. The samples of teas drawn were tasted by the Tocklai, Calcutta and London panel of tasters. The results are shown in Table 3.

Table 3. Taster's evaluation of teas packed in different packaging materials (Tocklai Taster)

Date	Polycoated Hessian Bag	Polylaminated Hessian Bag	Polylaminated Bitumen Hessian Bag	Control	Remark
19.10.74	5.00	6.00	5.00	6.50	No taint
19.11.74	7.00	6.00	6.00	7.00	
19.12.74	6.00	6.00	5.50	6.50	
Average	6.00	6.00	5.50	6.67	

Table 3 shows that there was no taint in the teas stored in experimental material. But, the teas stored in plywood chest, was found to be better and was preferred compared to the experimental materials. However, there was practically no difference between the Polycoated and Polylaminated bags. Teas stored in Polylaminated bitumen bag received lowest valuation.

Teas stored in boxes made of Plasticoated White Paper and Plasticoated Glassine Paper did not get tainted. The teas stored in the box made of Plasticoated Glassine Paper was preferred.

Dual Manufacture with different extractions

The object of the experiment was to find out the effect on the cup characters of made tea in three different extractions of fines. An attempt was made to extract 15%, 20% and 30% fines from a representative quantity of bulk leaf divided into three equal portions for making of orthodox tea and the coarse leaves for CTC tea.

The results of the experiment are not conclusive and further experiments are contemplated.

Dual Manufacture with different clones

Further attempts were made to find out the performance of some of the Tocklai released clones viz., TV1, TV9, TV10, TV12, TV16, TV17, TV18 and TV19 on dual manufacture. On each occasion two kilograms of leaf from each of these clones were manufactured in the miniature factory.

Table 4. Average valuation over occasions for different clones and tasters

Clone	Tasters	West Bengal		Tocklai	
	Method of Manufacture	Orthodox	C.T.C.	Orthodox	C.T.C.
TV--1		10.06	6.76	8.04	6.97
TV--9		8.73	6.60	6.21	6.95
TV—10		7.99	6.91	6.69	6.62
TV--12		10.01	6.35	7.71	6.85
TV--16		9.72	6.49	7.19	6.96
TV--17		11.51	6.49	8.37	7.00
TV--18		7.87	6.45	6.01	6.62
TV--19		7.74	6.39	6.56	6.64
Critical difference at	5%	0.75	NOT SIGNIFICANT	1.05	0.28
	1%	1.01	-	1.42	0.37
	0.1%	1.33	—	1.87	-

Samples of made tea were tasted on each occasion by the West Bengal and Tocklai tasters. The average valuation over occasions for different clones and tasters are given in Table 4.

The results, shown in Table 4, confirm our previous findings that the quality of TV17 is approaching towards that of TV1 (Annual Scientific Report 1973-74, P. 62) by orthodox manufacture, the tip content of TV17 was found to be more than the other clones. It may be mentioned here that in evaluating the orthodox teas, the leaf appearance and tip content were taken into consideration.

Green Tea

As a part of the product diversification measures suggested by the Tea Industry and desired by the Tea Board, the Director included a study on green tea manufacture at Tocklai in the departmental programme of work.

Although Tocklai miniature factory was not fully equipped with the miniature machines a few manufacturing trials were carried out in this factory with the existing machines. Samples of green tea were sent to Japan and the Tea Board for evaluation. These were also tasted by Tocklai tasters and analysis were carried out for biochemical estimations. The results were, encouraging. Intensive study will be undertaken in the next year.

Long-term clonal trial

From a long term clonal selection trial conducted by the Botany Department in collaboration with this Department, green leaf samples of 44 clones were manufactured throughout the season in the miniature factory, both by orthodox and C.T.C. methods, for evaluation of their cup characters. These teas were tasted on 15 occasions at Tocklai, West Bengal and on a few occasions at London by the panel of tasters.

From the summarised results it appears that four clones are of promising quality.

Manufacture from single bush

During 1974 leaf samples from each of the 23 bushes under trial for selection were manufactured in the miniature factory by the CTC method for evaluation of their cup characters. These teas were tasted at Tocklai. From this evaluation, three bushes were found to be promising.

Differentiation of clones and jats

This experiment was carried out by the Biochemistry Department in collaboration with this Department to differentiate clones TV19, TV20 and a jat. For this purpose 50 samples were manufactured in the miniature factory by CTC method during the year. These teas were tasted by the Tocklai Tasters and found hardly any difference amongst these three.

Effect of management practices on cup characters of made tea

During the year two Tocklai released clones TV1 and TV18 were studied to find out the effect of pruned and unpruned on cup characters of made tea.

This study was initiated by the Biochemistry Department, but no conclusion could be drawn from this. So it was proposed to continue this study.

The following experiments were conducted by the Agronomy Department in collaboration with this department for tasting and evaluation of teas manufactured from various treated plots.

(i) Different methods of plucking.
(ii) N. P. K. manuring.
(iii) Effect of zinc.
(iv) Long term weedicide trial.

The results of all the four experiments were not conclusive. It was proposed to continue this study in the next season.

Tea Tasting

During the season 10,995 samples were tasted. This consist of 3150 samples from Tocklai, 3966 samples from estates for advising on manufacture and 3879 clonal samples from estates.

Engineering Research & Development Department

RESEARCH & EXPERIMENTAL ROLLING

Continuous Green Leaf Processing Machines

1. **Disc Type Continuous Roller :** The 122 cm (48") Commercial Prototype Disc Roller which was sent back to the Licensees, Port Engineering Works, is now being copied by them for commercial production. The first unit of the commercial version of the machine is expected to be ready by the next season. The current recommendation for using this machine is that it should supplement the conventional rollers for the second and subsequent rolls. Enquiries for its use in conjunction with orthodox rollers and C.T.C.'s have been received from many quarters. Leaf passed through the Disc Roller is ideally conditioned for C.T.C. cuts. Meanwhile design modifications are being done with the 76 cm (30") prototype Disc Roller at Tocklai to improve its twisting action still further. The work of modification and fabrication is progressing satisfactorily.

2. **Cutter Attachment for B.L.C. and Rotorvane:** The manufacturing rights for this attachment has since been given to Port Engineering Works. The design details for both the versions of this attachment have been finalised by them and the first few cutter attachments are currently under commercial production. Although original intention of getting the cutter fabricated from stainless steel plates has not been given up, search is being continued for alternative alloys which have intrinsically high wearing and mechanical properties in respect of hardness and toughness. One alloy manganese bronze, as used in ship's propellers, is being actively considered. Tests and commercial manufacturing trials in collaboration with member estates would be initiated as soon as the commercial version of the cutter attachment is made available.

3. **Continuous Tea Roller :** The 45 cm (18") prototype Continuous Tea Roller fabricated at Tocklai was sent for trials under commercial conditions at Towkok T.E. where it was installed since the first week of June and was tried out till the first week of September under the supervision of the Second Research Engineer. The machine was tried with different modifications and adjustments with withered leaf alone, to developing it into a machine capable of doing the entire rolling process all by itself. To complete the first roll the same leaf was passed twice through the machine. But for the second and subsequent rolls leaf was passed only once through it. The monthly average valuations and assessments of leaf appearance based on Tocklai 'Tasters' reports on these teas in comparison with that estate's normal day to day manufacture are shown in Table 1.

Table 1. Results of Continuous Tea Roller Experiment at Towkok Tea Estate in 1974 for 100% orthodox manufacture

Month	No. of comparative tests	Particulars of samples	Average Valuation Rs./Kg.		Average points on leaf appearance	
			Continuous Tea Roller	Normal	Continuous Tea Roller	Normal
June	9	1st fine	6.34	6.83	7.77	9.88
		2nd fine	6.28	6.57	7.66	8.66
		3rd fine	6.00	6.58	7.33	8.00
		Coarse	5.93	6.26	5.00	7.77
July	9	1st fine	6.21	6.50	6.66	7.88
		2nd fine	6.21	6.70	5.55	8.00
		3rd fine	6.50	6.54	5.77	6.00
		Coarse	6.26	6.52	5.66	6.88
August	22	1st fine	6.27	6.64	7.00	8.18
		2nd fine	6.52	6.63	5.75	8.10
		3rd fine	6.15	6.75	6.16	6.83
		Coarse	6.42	6.50	5.71	7.85
September	3	1st fine	6.53	6.76	9.66	10.33
		2nd fine	6.50	6.70	6.66	8.33

A few trials with the Continuous Tea Roller were also made for dual manufacture at Towkok T.E. The average results based on tasters' reports are given in Table 2.

Table 2. Results of Continuous Tea Roller Experiment at Towkok T.E. in 1974 for Dual manufacture

No. of comparative tests	Particulars of sample	Average Valuations Rs./Kg.		Average points on leaf appearance	
		Continuous Tea Roller	Normal	Continuous Tea Roller	Normal
16	1st fine	6.33	6.71	7.60	8.79
	2nd fine	6.46	6.65	7.94	8.86
	C.T.C.	6.54	6.41	9.02	9.83

The points on leaf appearance mentioned in Table 2 are attributed to different aspects as shown in Table 3.

Tables 1 and 2 show that both in dry leaf appearance and liquor character, the Continuous Tea Roller needs a little improvement to replace the conventional table rollers entirely to produce orthodox teas. In dual manufacture C.T.C. teas produced from the coarse mal of the Continuous Tea Roller were valued higher, but the appearance of these teas was reported to be slightly inferior. Modification work for further improvement of this machine was taken up after these trials and was completed during the early part next season. The machine is scheduled to be tried out under commercial conditions at Barbam factory in 1975.

Table 3. Attributes to test appearance

Dry Leaf Colour		Make		Colour content of tip	
Attribute	Point	Attribute	Point	Attribute	Point
Black	4	Well twisted	6	Golden tip	5
Blackish	3	Fairly well twisted	4	Mixed tip	3
Blackish/Greyish	2	Fairly twisted	2	Silvery & pale tip	1
Greyish	1	Loosely twisted	1		
Grey/Brown	0	Open flat	0	No tip	0

4. **Withered leaf Preconditioner for Orthodox teas:** In the course of development of various continuous machines for orthodox manufacture, it was invariably found that orthodox leaf appearance and liquor characteristics can only be obtained if the leaf blades and stems are subjected to repeated bending and twisting action, which helps in fatiguing the leaf cells in the mechanical sense. Once these cells are mechanically fatigued by the above process, twisting and retaining the twist on them become an easy matter.

To do this, a withered leaf preconditioner, which is a simple device consisting of four pairs of 6" dia wooden rollers each 10" long arranged one pair above another in four high was constructed and tried out at Tocklai in conjunction with prototype Disc Roller and Conventional Rollers only. The results obtained from these experiments, as shown in following tables 4, 5 and 6, are very encouraging indeed.

Table 4. Valuation in Rs./Kg. by Tocklai Panel of Tasters

Date of manufacture	Method of manufacture	1st fines	2nd fines	Coarse
27.11.74	Pre-conditioner (@ 60 rpm. + Disc Roller	6.00	6.05	6.05
	Disc Roller only	6.50	6.00	5.00
	Conventional Roller	7.00	7.00	6.50
5.12.74	Pre-conditioner at 115 rpm. +Disc Roller	5.55	5.60	5.00
	Pre-conditioner (@ 60 rpm. Disc Roller	6.00	5.10	4.20
	Disc only	6.00	5.15	3.90
6.12.74	Pre-conditioner (@ 115 rpm. + Conventional Roll	5.50	5.05	3.90
	Pre-conditioner @ 60 rpm. + Conventional Roll	6.50	5.10	5.10
	Conventional Roll	6.00	5.50	5.15

Table 5. Biochemical Assessment of teas, Date of manufacture 27.11.74

	Disc Roller			Pre-conditioner 1 Pass Disc Roller			Conventional Roller		
	%TF	%TR	Valuation	%TF	%TR	Valuation	%TF	%TR	Valuation
1st fine	0.95	9.82	Rs. 6.50	0.90	9.47	Rs. 6.00	1.08	11.34	Rs. 7.00
2nd fine	0.93	11.07	Rs. 6.00	0.90	9.88	Rs. 6.05	1.12	14.34	Rs. 7.00
Coarse	0.73	8.91	Rs. 5.00	0.70	10.79	Rs. 6.05	0.82	10.68	Rs. 6.50

Table 6. Biochemical assessment of teas Date of manufacture. 5.12.74

	Disc Roller			Pre-conditioner * 60 rpm. + Disc. Roller			Preconditioner 115 rpm. + Disc Roller		
	%TF	%TR	Valuation	%TF	%TR	Valuation	%TF	%TR	Valuation
1st Fine	0.65	8.11	Rs. 5.55	0.55	8.54	Rs. 6.00	0.74	9.03	Rs. 6.00
2nd Fine	0.76	9.13	Rs. 5.60	0.64	8.28	Rs. 5.10	1.00	10.39	Rs 5.15
Coarse	0.53	7.17	Rs. 5.00	0.40	5.60	Rs. 4.20	0.61	7.32	Rs. 3.90

In view of encouraging results obtained with this machine, work on adding a set of 8 more rollers to complete a machine of 16 rollers on a 8 high machine has been taken in hand. The effective size of the rollers was still kept at 10" for the sake of uniformity. It is expected that this prototype unit will be tried at Dufflaghur T.E. on 100% orthodox manufacture. Fabrication and machine work in connection with this machine is progressing satisfactorily.

5. **Machining Specifications for C.T.C. Segments:** In 1971-72, trials were initiated at the pilot factory with three sets of mini C.T.C. rollers to study the effect of different machining specifications, and from the results of these trials recommendations were given to those who require more of PF and Dust grades, to go for 60 helical grooves per segment and 10 circumferential grooves per inch keeping the land to flank ratio 1:1. Commercial factories utilising these specifications have reported improved results compared to the teas manufactured with standard segments having 50 helical grooves and 8 circumferential grooves per inch. One of the snags in having 10 circumferential grooves is that with a groove angle of 55° the depth of the chased groove cannot exceed 0.0625" in 10 TPI segments compared to 0.080" in standard 8 TPI segments. As a result throughput suffered.

To rectify the defect, experiments were carried out with 10 TPI segments where the groove angle was changed from 55° to 45°. The changeover from 55° to 45° enabled us to achieve a chased groove 0.078" deep and thus the milled groove was also increased from 0.050" in 10 TPI 55° grooved segments to 0.068" in 10 TPI 45° grooved segments.

Teas were manufactured and samples were sent for evaluation and tasting to Tocklai, Calcutta and London panel of Tasters. Reports from Calcutta are not received yet. The average valuation and comments obtained from graded tea samples from Tocklai and London panel of Tasters are shown in tables 7 and 8.

The grades percentages showed the trend as shown in table 8.

The grade percentages indicate that total of broken grades are reduced from 32.18% to 27.89% while fannings and dust percentages are increased from 66.29% to 70.50% without any appreciable increase in the residue percentages.

Typical comments on these experimental teas are as follows : -

Tagle 7. Evaluation of Tea.

Date of manufacture	Tocklai Valuation Rs/kg.		London Joints	
	Normal 50 helical 8TPI 55° grooves	Experimental 60 helical 45° grooves	Normal 50 helical 8TPI 55° grooves	Experimental 60 helical 45° grooves
18.7.74	6.90	6.75	5.87	6.58
20.7.74	6.64	6.96	3.58	4.03
27.7.74	6.98	6.45	4.96	6.47
10.8.74	6.46	6.50	4.00	6.67
24.8.74	6.15	6.41	3.42	5.68
4.9.74	6.14	6.44	6.01	5.24
Average	6.55	6.59	4.64	5.77

Table 8. Grade percentage of tea

	Normal 8 TPI 50° grooves 50 helical	Experimental 10° TPI 45° grooves 60 helical
BP_1	21.30%	18.57%
BP_{11}	10.88%	9.32%
PF_1	49.94%	52.27%
PF_{11}	9.62%	11.11%
Dust	6.73%	7.12%
Residue	1.01%	1.61%

"Sample C (Experimental) contains less fibre compared to sample A (Normal)" (Tocklai Panel).

"Overall preference for "A" (experimental) when taking account of leaf and liquor" (London Panel).

Recommendations in this regard is published in the December 1974 issue of the "Two and A Bud".

Fermentation

Continuous Fermenting Machine: The S.F. version of the Continuous Fermenting Machine installed at Ethelwold Tea Estate in Upper Assam was in use during the year. According to the Managing Director of the Tea Company the results obtained from the Continuous Fermenting Machine during the hot spell in May were far superior to those obtained by other methods of fermentation viz. Fermenting troughs or floor fermentation. As a result thereof, according to him, Ethelwold's C.T.C. teas fetched the highest price on this group.

The S.F. design which utilised woven wire mesh endless band as the leaf carrier has since been altered by the manufacturers to perforated trays because of the difficulty in retaining the wire mesh in position and the excessive sagging of the wire mesh band which was difficult to control. In the meantime, S.F. has formally declined to enter into an agreement with the T.R.A. on certain differences regarding the terms and conditions. The Engineering Sub-committee of the T.R.A. has considered the matter and has decided to award manufacturing licence to Tea-Ma Consortium of Calcutta. The other licensee Steelsworth of Tinsukia has not produced a single unit of this machine so far.

From the study of the behaviour of the machine in commercial use, it has been suggested by the user that perhaps the machine performance will be much better if the width is reduced to 122 cm (4 ft.) instead of the present 183 cm (6 ft.). The costing of the machine with this reduced width will be gone into with the eventual manufacturers.

Sorting

Sorting Machinery for Continuous Sorting of Teas : Preliminary work has been taken in hand to design a simple sorter incorporating cleaning and deballing devices to enable producers of C.T.C. teas to sort out the grades continuously on the same day thereby eliminating the necessity of bulk storage which in many ways detrimental to the teas. The fabrication work has been taken up at the workshop.

Testing of Commercially available tea cleaning machines : A slow speed fibre extractor supplied by M/s. Saharia Engineering Industries Pvt. Ltd. of Dibrugarh was tested for its fibre and fluff picking ability. The results of the trial with CTC teas are shown below.

Sorting Room Temperature	65–69°F D.B. 61–64°F W.B.
Fibre content of the teas	2 to 4% by weight.
Fibre extracting ability of the machine	91 to 94% by weight.
Rate of feed	300 to 306 kg per hr.
The gap between the 8" Dia PVC. Roller and the vibrating type myddleton tray	5 cm (2")
Speed of PVC Rollers	12 rpm.
Speed of the crank-shaft.	400 rpm.
Throw of the Crank shaft	1.08 cm. (3/8")

The fibre extractor was found to be satisfactory in its performance as such.

Plucking

Power Operated Plucking Aid: The Engineering Division of Shaw Wallace Company of Madras, our collaborators in the development of this aid, had some difficulties in getting some components for making the Mark IV type of Plucking Aid. Hence there was some delay and the aid could be made ready towards the end of this year. Trials with this aid will be taken up during the next year.

General

The Junior C.S.I.R. Research Fellow attached to the Department continued his experimental work for further elucidation of the principles as suggested by Sir Frank Engledow and L.S.C. on his paper entitled "Some Comparatively Lesser known Physical Parameters of Fresh and withered Tea Shoot".

The Senior Research Engineer now also heads the Tea Tasting Department of Tocklai. In that capacity he had to organise training and tasting programmes of the Tea Tasting Department. Sometime had to be devoted by him on administrative and technical matters relating to that Department.

As a result of the changeover of ownership and frequent lock-outs and other disturbances, all the licensees of Tocklai developed machinery were hard put to keep their concerns going. Consequently considerable time had to be dovoted by the Senior Research Engineer to induce the licensees to get the machines manufactured or attended to, in order to keep up the reputation of the Tocklai developed tea machinery.

In connection with the above and some patent matters and also for the finalisation of Tea Board's Instant Tea Project to be initiated at Tocklai the Senior Research Engineer had to visit Calcutta seven times during the year. He also attended one meeting of the Engineering Sub-Committee in Calcutta. He attended the Silver Jubilee Celebration of M/s. Steelsworth of Tinsukia as a Tocklai representative. He paid another visit to Steelsworth in connection with improvement and modification of the Tocklai Continuous Drier, Mark II. As a result of his suggestions the height of the machine could be reduced by approximately 38 cm and the price was reduced by Rs. 10,000/- per machine. The Senior Research Engineer also attended two meetings of the I.S.I. in Delhi and Bangalore.

The Senior Research Engineer gave a seminar on "Pruning and Plucking in relation to manufacture" at the Gariajan Club of Golaghat on 14.10.74 and another seminar on manufacturing and Engineering at Dewan Tea Estate in Cachar on 16.11.74. He paid 34 advisory visits to different factories during the year.

The Second Research Engineer was mostly occupied with the fabrication, evaluation, modification and trial of the prototype Continuous Tea Roller under trial at Towkok T.E. He visited Calcutta once in connection with matters relating to the patent for the Continuous Tea Rollers. He visited four tea factories and Steelsworth of Tinsukia in connection with some engineering problems and the Engineering Seminar scheduled to be held next April.

Statistics Department

Sampling and Experimental Technique

Sampling of plucking rounds : The objective of this study was reported in the Annual Scientific Report for 1973-74, p. 69. For detailed study, large number of experiments continued for a number of years covering all aspects of tea culture in all regions of North-East India have been selected. Due to complicated nature of analysis involving a large mass of data, the computations of this study have to be carried out on the electronic computer. For this purpose data recording system on the card has been designed. Scrutiny and compilation of weekly plot yields, number of bushes per plot, number of replications and other details of these experiments are in progress.

Crop-Weather Studies

The results obtained from a study on crop and rainfall data for the Jainti and Kalchini sub-districts of Dooars were reported in the Annual Scientific Report for 1973-74, pp. 69-72. Here results obtained from a similar study in the Dam Dim sub-district of Dooars will be reported.

Dam Dim Sub-district

This study showed that rainfall during the seven periods, namely, October and November-December of the previous season, and January to March, April, May, June and July-September of the current season were all critically associated with the annual yield of tea in this sub-district. Rainfall during these seven periods together contributed about 80 per cent towards the annual yield. The relative contributions due to November-December, April and May rains were, however, more than the remaining four periods rains in this sub-district.

Following equation (Equation 1) derived from the set of data under investigation revealed the types of relationship between annual yield of tea and the rainfall during the seven critical periods :

$$Y = 3.8107\ R_1 + 178.4583\ R_2 - 17.7920\ R_3^2 + 12.9555\ R_3 + 18.0250\ R_4 + 8.3765\ R_5 - 1.6580\ R_6 + 107.5745 \log_{10} R_7 + 543.3673 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where, Y = annual yield of made tea in kg/ha; R_1, R_2, R_3, R_4, R_5, R_6 and R_7 are rainfalls in cm during October and November-December of the previous season, January-March, April, May, June and July-September of the current season respectively.

Equation (1) suggested that the annual yield increased with the increase in rainfall during October of the previous season at a constant rate of 3.81 kilograms of made tea per ha per centimetre upto the maximum rainfall observed during this period. Whereas, rainfall during November-December showed beneficial effect on yield upto about 5 cm, but beyond that limit yield declined. Further, rainfall during January-March, April and May showed beneficial effect on the annual yield upto the observed maximum of 15 cm, 34 cm and 50 cm respectively; the relationship being linear between rainfall during respective period and the annual yield. Thus, in all the five periods rainfall showed beneficial effect on the yield except that excess rainfall beyond 5 cm during November-December showed detrimental effect.

On the other hand, yield decreased with the increase in rainfall during June from the minimum observed, i.e., from 53 cm to the maximum observed, i.e., 110 cm. Rainfall during July-September showed beneficial effect on the yield but the rate of increase in yield gradually declined as the rainfall increased and at the observed maximum rainfall of 297 cm, the rate of increase was practically nil. Even at the observed minimum rainfall of 193 cm, the rate of increase was very negligible.

The study of the rainfall data showed that in almost all the years rainfall during October, November-December, January-March and April were much less than the rainfall upto which yield was

found to increase during these periods, i.e., 40 cm, 5 cm, 15 cm and 34 cm respectively. This was obvious as the average rainfall during October, November-December, January-March and April were only 16 cm, 2 cm, 8 cm and 14 cm respectively over the years under study (Table 1). These showed that

Table 1. Rainfall and quantity of irrigation requirements during critical periods and the estimated gain in annual yield due to irrigation

Region : Dam Dim sub-district of Dooars

Critical period	Rainfall in centimetre			Average irrigation requirement with economic return (cm)	Yield of made tea in kg/ha		
	Minimum	Maximum	Average		Actual average	Estimated with optimum irrigation	
						Average	Gain
October (Previous Season)	5	40	16	Uneconomic			
November to December „	0.1	8	2	3			
January to March (Current Season)	2	15	8	7	1493	2228	735
April („ „)	7	34	14	20			
May („ „)	14	50	29	Uneconomic			
June („ „)	53	110	80	Drain out excess water			
July to September („ „)	193	297	248	—			
Total irrigation requirement →				30			

on an average there were deficiencies of rainfall during October, November-December, January-March and April by at least 24 cm, 3 cm, 7 cm and 20 cm, respectively (Table 1). These results suggested that if these deficiencies were compensated by irrigation, there would be a gain in yield. But the gain in yield per unit centimetre of rainfall during October was such that it would unlikely to pay for the cost of irrigation. Whereas during November-December, January-March and April it would pay, because the return in yield per unit centimetre of rainfall during these three periods were much higher than that during October. During May, although average rainfall was less than the observed maximum of 50 cm upto which yield was found to increase (Table 1), but in most of the years it exceeded the average, which meant that deficiency of rainfall during this period was not very acute. Moreover, the gain in yield per unit centimetre of rainfall during this period was such that it would most unlikely to pay for the cost of irrigation.

The types of relationship and the rainfall distribution in the Dam Dim sub-district, therefore, suggested that if irrigation was adopted to compensate the average water deficiencies of 3 cm, 7 cm and 20 cm during November-December, January-March and April respectively, and adequate measure was taken to drain out the excess water during June, annual yield could be increased considerably (Table 1). By using Equation 1, average annual yield was estimated to increase from 1493 to 2228 kilograms of made tea per hectare, which was equivalent to 49 per cent (735 kilograms of made tea per hectare) increase over the actual average (Table 1). From the economic point of view, this study showed that replenishment of rainfall deficiency by irrigation from November to April would be a paying proposition in this sub-district.

Following important points need be stressed in the interpretation and implementation of the above results.

(*i*) *Estimated gain in yield due to irrigation would mainly depend on the period of irrigation, quantity of irrigation in each period and draining out the excess rain water during the critical monsoon period mainly during June as shown in Table 1.*

(*ii*) *The results presented here are conspicuous to the average soil-climatic conditions for the sub-district*

as a whole. Therefore, if irrigation is proposed for any individual estate, it should be governed by a careful examination of such factors as distribution of rainfall, soil type, depth of soil, etc.

(iii) Irrigation requirements as suggested need to be tested by actual field experiments before large scale programme is adopted.

Survey on Field Management and Environmental Factors Affecting the Yield of Tea

(i) *Dooars & Terai, West Bengal* : The object of this survey was reported in the Annual Scientific Report for 1972-73, p. 79. Some of the computations of the large mass of data, collected from 112 member estates' records in the Dooars and Terai for each section covering 16 years, were carried out on an ICL 1901A electronic computer at Digboi, for which four programmes were written in COBOL language. The results obtained so far are summarised below.

(a) Soil type × Nitrogen × Age : Analysis of the data showed that annual yield of tea increased with the increase in Nitrogen level upto the observed maximum of 150 —≤180 under Loamy Sand, Mai Sand and Silty Loam; under Silty Clay Loam, Loam and Sandy Loam upto the observed maximum of 120 —≤150; and under Red Bank and Clay upto the observed maximum of 90 —≤120 kilograms of Nitrogen per hectare.

Table 2 shows that the return in yield from unit kilogram of Nitrogen varies from soil type to soil type and also within soil type between levels of Nitrogen. Further, under all soil types, the return in yield increased with the increase in Nitrogen level upto a certain level, and beyond that the return declined. This increasing trend of return from unit kilogram of Nitrogen upto a certain level of Nitrogen application is not in agreement with the experimental findings and the reasons for this should be considered. However, the level of Nitrogen at which the return declined varies soil type to soil type.

Table 2. Average return in yield from unit kilogram of Nitrogen at different levels of Nitrogen application on tea above 7 years by soil types

(Made tea in kg/ha)

Level of Nitrogen (kg/ha) / Soil type	0—≤30.0	30.1—≤60.0	60.1—≤90.0	90.1—≤120.0	120.1—≤150.0	150.1—≤180.0	Over all Nitrogen levels
Loamy Sand	×	* (25)	5.14 (96)	9.02 (113)	5.00 (62)	3.40 (6)	5.64 (302)
Mal Sand	* (27)	3.28 (118)	4.54 (1175)	4.30 (586)	2.97 (102)	2.31 (7)	3.48 (2015)
Silty Loam	* (10)	3.40 (160)	4.24 (953)	2.96 (379)	2.91 (111)	0.30 (8)	2.76 (1621)
Sandy Loam	* (325)	2.08 (985)	4.72 (6253)	4.26 (1895)	3.19 (775)	×	3.56 (10233)
Loam	×	* (74)	2.85 (389)	4.78 (50)	2.66 (247)	×	3.43 (760)
Silty Clay Loam	×	* (38)	4.62 (178)	5.11 (43)	2.70 (56)	×	4.14 (315)
Red Bank	* (26)	3.52 (314)	4.94 (1564)	3.55 (640)	×	×	4.00 (2544)
Clay	×	* (6)	2.94 (175)	3.67 (96)	×	×	3.30 (277)
Over all Soil types	(388)	3.07 (1720)	4.25 (10783)	4.71 (3802)	3.24 (1353)	2.00 (21)	(18067)

N.B. : * : Base point.
× : Data not available.
( ) : Figures within bracket indicate number of observations.

Under Loamy Sand the return in yield from unit kilogram of Nitrogen at all levels of Nitrogen was highest compared to that under other soil types. Again, the return reached its maximum of 9.02 kilograms of made tea at 90-≤120 kilograms of Nitrogen per hectare and beyond that gradually decreased to 3.40 kilograms of made tea at 150 ≤ 180 kg Nitrogen level. Similarly, under Loam and Silty Clay Loam, the return reached maximum of 4.78 and 5.11 kilograms of made tea at 90-≤120 kg Nitrogen level and beyond that it decreased to 2.66 and 2.70 respectively at 120 ≤150 kg Nitrogen level. Whereas under Mal Sand, Sandy Loam, Red Bank and Silty Loam, the return reached maximum at 60-≤90 Nitrogen level. It is also interesting to note from Table 2 that under Loamy Sand and Mal Sand, the return in yield from unit kilogram of Nitrogen at 150-≤180 level was considerable, whereas under Silty Loam at the same level of Nitrogen it was practically nil. Further, under the remaining soil types, more or less similar rates were found at the respective observed maximum level as found under Loamy Sand and Mal Sand at 150 ≤180 level of Nitrogen. It may be mentioned here that though the number of observations at 150-≤180 kg Nitrogen level was much less as compared to that at other lower levels of Nitrogen, but these results indicate that under Loamy Sand and Mal Sand, application of Nitrogen upto 165 kg/ha is likely to be profitable, while under Silty Loam, application beyond 135 kg/ha may not be profitable. Further, under other soil types, the return in yield from unit kilogram of Nitrogen suggests that application of Nitrogen upto the respective observed maximum level may be profitable. These results throw light for further research in this direction.

The study of the data showed that annual yield of tea increased with the increase in Nitrogen level upto the respective observed maximum level for all age groups of tea and under all soil types. But the return in yield from unit kilogram of Nitrogen varied from age group to age group within soil type and also between soil types within age group. From Table 3 it can be seen that in general, under all soil types, the return in yield from unit kilogram of Nitrogen gradually increased with the age and reached its maximum at age group 11-≤20 years. Beyond 20 years old tea, the return decreased and thereafter, that remained more or less constant.

This result suggests that in order to obtain maximum benefit from limited Nitrogen resource, it should be allocated to areas where from maximum return can be expected.

It is, however, stressed that the results obtained from this survey with respect to soil types, i.e., the variation from soil type to soil type in respect of return from unit kilogram of Nitrogen and the level of Nitrogen at which the return declined, were not observed in the various Nitrogen experiments so far conducted under various soil types. These findings, therefore, demand further research in this direction.

(*b*) *Drainage* × *Nitrogen* × *Age* : The type of relationship between annual yield of tea and nitrogen levels showed that yield increased with the increase in Nitrogen level upto the maximum level observed under respective drainage conditions and age groups. The yield under good drainage condition was, however, higher than that under poor drainage condition at all levels of Nitrogen. Further, the return in yield from unit kilogram of Nitrogen varied between poor and good drainage conditions within Nitrogen level and age group as well as between Nitrogen levels within drainage condition and age group. Also, the return varied between age groups within drainage condition and Nitrogen level. These variations in return in yield from unit kilogram of Nitrogen are shown in Table 4.

From the table (Table 4) it is interesting to note that in general under good drainage condition, the return in yield from unit kilogram of Nitrogen, averaged over all age groups, was practically double than that under poor drainage condition at all levels of Nitrogen. Moreover, the return in yield under good drainage was considerable, upto 120-≤150 Nitrogen level, whereas under poor drainage condition it was very small beyond 90-≤120 Nitrogen level. Further, the return in yield beyond 90 ≤120 Nitrogen level from above 20 years old tea planted under poor drainage condition was very small compared to that of tea upto 20 years old. The result also indicated that under good drainage condition, application of Nitrogen upto 165 kg/ha on tea between 11 and 20 years old may be profitable. Here again, the number of observations at 150-≤180

Table 3. Average return in yield from unit kilogram of Nitrogen within the observed level of Nitrogen (kg N/ha) applied on different age-groups of tea under various soil types

(Made tea in kg/ha)

Age-group (in year) / Soil type	7.1 - ≤11.0	11.1 - ≤20.0	20.1 - ≤40.0	> 40
Loamy sand	-	7.25 (21)	6.29 (156)	5.68 (122)
Mal Sand	2.48 (168)	4.66 (262)	3.89 (534)	3.70 (1051)
Silty Loam	3.86 (151)	4.51 (59)	2.74 (111)	2.76 (1300)
Sandy Loam	3.88 (482)	3.91 (717)	3.93 (2797)	3.17 (6237)
Loam	3.07 (42)	5.45 (38)	3.19 (142)	3.16 (538)
Silty Clay Loam	-	-	4.15 (46)	4.04 (269)
Red Bank	3.61 (174)	5.70 (247)	3.46 (972)	3.86 (1151)
Clay	3.02 (42)	4.53 (22)	3.81 (116)	3.45 (97)
Over all Soil types	3.32 (1059)	5.14 (1369)	3.94 (3874)	3.73 (10765)

N.B.: - : Data not available.
( ): Figures within bracket indicate number of observations.

level was much less as compared to that at other lower levels of Nitrogen and, therefore, further investigations in this direction are called for.

These results, therefore, suggest that apart from double return from unit kilogram of Nitrogen due to efficient drainage system as compared to poor drainage system, more return can also be obtained from mature and old tea at high level of Nitrogen.

(c) Vacancy Percentage × Nature of Soil (Virgin & Replanted) × Age :

The type of relationship between annual yield of tea and percentage vacancy of tea bushes showed, that in general, loss in yield for each per cent of vacancy was lower at the lower level of vacancy than at the higher level upto the respective maximum vacancy observed at different age groups, both under virgin and replanted soil. But the loss for each per cent of vacancy varied between virgin and replanted soil within age group and also between age groups within virgin or replanted soil. Table 5 shows the average rate of loss in crop for each per cent of vacancy for different age groups under virgin and replanted soil.

This average rate of loss in crop was calculated on the basis of respective maximum percentage of vacancy observed.

Table 5 shows that the average loss in crop for each per cent of tea bush vacancy is more under virgin soil than that under replanted soil upto 15 years of old tea. This result indicates that the yielding capacity of young and youngish mature tea under virgin soil is higher than those under replanted soil. Further, beyond 15 years old, practically no difference exists in the rates of loss in crop between tea under virgin and replanted soil. This is possibly due to full ground coverage by the mature tea when the yielding capacity of bushes under virgin and replanted soil becomes equal. It is also noticed from the table (Table 5) that the rate of loss in crop due to vacancy gradually increases with the age of tea upto 15 years old both under virgin and replanted soil. But, beyond 15 years old, the rate of loss is reduced to almost half, and thereafter, nearly the same rate of loss is maintained under both the soil.

These results suggest that in order to avoid loss in crop proper attention should be paid to infill

Table 4. Average return in yield from unit kilogram of Nitrogen at different levels of Nitrogen application on tea under poor and good drainage conditions by age group

(Made tea in kg/ha)

Drainage condition	Age-group (year in)	Level of Nitrogen (kg/ha) 0 - ≤ 30.0	30.1- ≤60.0	60.1- ≤90.0	90.1- ≤120.0	120.1- ≤150.0	150.1- ≤180.0	Over all levels of Nitrogen
Poor	7.1 - ≤11.0	* (8)	×	1.83 (35)	1.11 (23)	×	×	1.47 (66)
	11.1 - ≤20.0	×	* (3)	3.32 (82)	3.79 (21)	2.09 (9)	×	3.07 (115)
	20.1 - ≤40.0	* (8)	1.76 (40)	2.90 (758)	2.50 (378)	1.37 (88)	×	2.13 (1272)
	>40	* (59)	0.99 (730)	2.75 (4203)	2.35 (1034)	1.35 (209)	0.40 (21)	1.57 (6256)
	Over all age-groups	* (75)	1.38 (773)	2.70 (5078)	2.44 (1456)	1.60 (306)	0.40 (21)	1.70 (7709)
Good	7.1 - ≤11.0	* (30)	0.62 (25)	3.55 (428)	4.01 (446)	3.56 (117)	×	2.94 (1050)
	11.1 - ≤20.0	* (2)	3.34 (78)	5.00 (594)	5.32 (523)	5.24 (174)	2.22 (4)	4.22 (1375)
	20.1 - ≤40.0	* (135)	2.12 (636)	4.86 (2468)	5.22 (698)	3.01 (156)	×	3.80 (4093)
	>40	* (147)	1.28 (330)	3.44 (3548)	4.62 (856)	3.19 (427)	×	3.13 (5308)
	Over all age-groups	* (314)	1.84 (1073)	4.21 (7038)	4.79 (2523)	3.75 (471)	2.22 (4)	3.36 (11826)

N.B. : * : Base point.
× : Data not available.
( ) : Figures within bracket indicate number of observations.

Table 5. Average rate of Loss in crop for each per cent of vacancy for different age-groups under virgin and replanted soil

(Made tea in kg/ha)

Nature of Soil	Age-group (in year) 3.1- ≤7.0	7.1- ≤11.0	11.1 ≤15.0	15.1- ≤20.0	20.1- ≤40.0	>40
Virgin	19.2 (246)	31.8 (188)	32.7 (149)	15.9 (131)	16.3 (1896)	14.2 (7750)
Replanted	17.1 (478)	27.9 (389)	30.3 (176)	15.3 (134)	14.7 (520)	14.5 (23)

N. B. : Figures within bracket indicate number of observations.

the tea bush vacancies, more so, for young and youngish mature tea where the loss in crop due to vacancy is very high.

(ii) *Darjeeling, West Bengal :* Collection of data on computerised questionnaire from the estates' records for last 20 years and for each section in all the member estates in Darjeeling has been started from November, 1974. These are being collected by four trained investigators, three from Tocklai and one from Darjeeling Advisory Department. The object of this survey is the same as outlined earlier in the Annual Scientific Report for 1972-'73, p. 79 for Dooars and Terai survey.

Help to other Departments

The Department continued to extend co-operation and help in solving statistical problems encountered by research workers of practically all the Departments of the Station. A number of experiments were planned, designed any analysed during the period.

Agricultural Economics Department

The rising trend in the cost of production of tea is causing concern to the tea industry, as the increase in cost is not matched by corresponding increase in the price of made tea. For the last one decade the cost of production is on the increase at a rate of about 8% per annum, but the price has remained static till 1973. This has resulted in financial loss to a number of tea estates in North-East India, and a large number of estates became economically unviable in the high cost areas. The world wide oil crisis and resultant inflation did boost up the tea price to a certain extent in 1974, but the trend seems to be a temporary one. In the long run the cost may continue to rise while the price may not rise proportionately. Therefore, proper corrective measures are essential if the estates are to be kept economically viable. Tocklai, as a pioneer research centre of tea has played a very vital role during the last 75 years in providing the industry with the scientific knowledge for better and improved techniques for production and manufacturing. But a stage has now come to take cognisance of the impact of economic factors on the recommendations made by Tocklai.

In view of this, in the Twentysixth biennial Tocklai Conference (1973) of the Tea Research Association, Tea Industry recommended the establishment of the Agricultural Economics Department.

The department started functioning in December, 1974 with the joining of the Agricultural Economist. The main objective of the department is (1) to study the economic feasibility of the various recommendations resulting from the research at Tocklai and (2) to study the economic aspects of various agricultural practices in operation in the tea estates of North-East India.

The task is not an easy one. The industry has also to play an important role by providing reliable data for studying the economic aspects of various practices and operations in their estates. This will then enable us to evolve the economics of the various practices and operations of the estates in the region.

To start with, the department is trying to focus attention upon estates level studies. Currently the following projects have been taken up for their economic evaluation.

(a) Replantation and Rejuvenation.
(b) Fetilizer application.
(c) Weed & pest control.
(d) Irrigation.
(e) Pruning Cycle.
(f) Input optimisation in factory.

The department started the first project, i.e., Economics of Replantation and Rejevenation in Assam Valley. A questionnaire was sent to 93 gardens for this purpose.

The Agricultural Economist is being helped by an experienced Cost Adviser.

Library and Publication Department

LIBRARY

General

Six new journals were added to the subscription list making the total of 131 journal heads in the Library. In addition to these the Library receives 94 journals in exchange of Tocklai publications, and on free basis. Arrangement has been made to subscribe the foreign journals through INSDOC, New Delhi, from the next year.

Reorganisation

Cataloguing and Classification of books are in progress. A Bibliography on tea is being compiled. Weekly accession lists of books, journals etc. are issued to Departments. Arrangements are being made to appoint one Cataloguer and one Documentation Assistant to cope with the increased work in the Library. Paper cuttings on important topics relating to tea and other subjects have continued to be preserved.

Loan Service

Tea Science students of under-graduate and Post-graduate classes of Assam Agricultural University; Scientists of Regional Research Laboratory, Jorhat; Tocklai Scientists; a few Professors of local colleges and State Govt. Officials utilised the Library during the year.

Book Binding

811 Books and Journal volumes were bound this year. Old reports and other documents of historical value were also bound.

Library Statistics

Total No. of Books —3887
Books added durng the year —121
Periodicals and Journals received—1274
New Journals added 6
Pamphlets and Bulletins—616
Maps 3
Reprints —106
Publications consulted in the Library 3054
Publications issued to Departments —1067

PUBLICATIONS

The activities of the Publication Section increased to render services to the new Members of TRA and Non-Members.

The following publications were issued from Tocklai :

1. **Two and A Bud** —Vol. 21, Nos. 1 & 2,
2. **Two and A Bud** Vol. 22, No. 1,
3. **Two and A Bud** Subject Index—Vol. 1, No. 1 to Vol. 21, No. 2.

Miscellaneous Reports

4. Proceedings of the Twentysixth Conference held at Tocklai on 13th, 14th and 15th November, 1973.

5. Annual Scientific Report for 1973-74.

6. Engineering Research & Development Department Quarterly Reports for quarters ending 30th June, 30th September, 31st December, 1974 and 31st March, 30th June 1975 (Circulation restricted).

7. Guide to Tocklai (Cyclostyled).

Appendix-A

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES

By

THE ADVISORY DEPARTMENT

South Bank, Assam

Project	Site	Index		Year of starting
Soil Rehabilitation trial	Sangsua	AS	103	1972
NPK manuring of mature tea	Panitola	AS	108	1973
-do-	Thowra	AS	111	,,
-do-	Rupai	AS	114	,,
-do-	Diffloo	AS	120	,,
Foliar application of Zinc	Panitola	AS	109	,,
-do-	Sepon	AS	112	,,
-do-	Daimukhia	AS	115	,,
-do-	Bokakhat	AS	121	,,
Shade in relation to Tea nutrition	Thorwa	AS	110	,,
-do-	Bordubi	AS	113	,,
-do-	Methoni	AS	119	,,
Urea Trial	Duklinga	AS	125	,,
Plucking experiment	Nahortolli	AS	126	1974
-do-	Lohpohia	AS	133	,,
Infilling experiment	Halmari	AS	129	,,
-do-	Kaliapani	AS	132	,,
Rejuvination	Tara	AS	128	,,
-do-	Teloijan	AS	130	,,
-do-	Khoontai	AS	131	,,

North Bank, Assam

Project	Site	Index		Year of starting
NPK Manuring of mature tea	Naborani	AN	123	1973
	Monabarrie	AN	116	1973
Shade in relation to level of tea nutrition	Dhulapadung	AN	122	1973
	Pertabghur	AN	118	1973
Response to Foliar application of Zinc	Tezpur & Gogra	AN	124	1973
	Monabarrie	AN	117	1973
Rejuvenation	Kachari-gaon	—		1974
	Tezpur & Gogra	—		1974
	Baghmari	—		1974
Infilling	Kachari-gaon	—		1974
	Baghmari	—		1974
Different methods of plucking	Dhullie	—		1974

Cachar, Assam

Project	Site	Index		Year of starting
Shade in relation to level of tea nutrition	Arcuttipore	C	42	1973
	Pathemara	C	43	1973
Response to foliar application of Zinc	Longai	C	41	1973
	Silcoorie	C	40	1973
NPK manuring of mature tea	Silcoorie	C	38	1973
	Longai	C	39	1973
Clonal Response to N in different Agro climatic regions	Coomber-gram	C	20	1962
Infilling	Longai	C	44	1974
Plucking	Hattikhira	C	45	1974
Rejuvination	Isabheel			1974
-do-	Longai			1974

Dooars & Terai, West Bengal

Project	Site	Index		Year of starting
Rehabilitation of Land	Bhogotpore	D	27	1964
	Grassmore	D	28	1964
NPK manuring of mature tea	Nimtijhora	D	57	1973
	Bagrakote	D	55	1973
	Sam Sing	D	56	1973
	Gungaram	TR	7	1973
Nitrogenous Fertilizer	Baradighi	D	33	1967
Clonal response to N in different Agro climatic region	Nyasylee	D	24	1962
Cultivation and Weed-control	Chuapara	D	42	1970
Shade	Nya Sylee	D	9	1958
Shade and nutrition	Dalgaon	D	51	1973
	Gandrapara	D	50	1973
Foliar application of zinc	Kartick	D	52	1973
	Bhogotpore	D	54	1973
	Baradighi	D	53	1973

Darjeeling

Project	Site	Index		Year of starting
Infilling	Kartick	D	41	1969
	Jainti	D	40	1969
	Fagu	D	37	1969
	Dem Dima	D	39	1969
	Sahabad	TR	4	1969
	Mohurgong & Gulma	TR	3	1969
Rejuvenation of old tea	Rydak	D	46	1972
	Dalgaon	D	43	1972
	Matelli	D	44	1972
	Killcott	D	45	1972
	Kumlai	D	47	1972
	Gungaram	TR	5	1972
Plucking	Birpara	D	58	1974
	Dalsengpara	D	59	1974
	Hansqua	D	60	1974
Clone Vs Nitrogen trial	Nagrakata	D	48	1973
Potash Soil sampling trial	Batabari	D	49	1973

Project	Site	Index		Year of starting
NPK manuring	Chongtong	Dj	34	1973
	Nagri Farm	Dj	35	1973
Nitrogenous Fertilizer	Lingia	Dj	29	1967
Clonal response to N in different Agro climatic regions	Nagri Farm	Dj	19	1961
P & K with and without weedicides	Chamong	Dj	31	1970
	Nagri	Dj	31	
	Sungma	Dj	31	
Pruning	Phoobsering	Dj	24	1965
	Margaret's Hope	Dj	27	1966
Foliar spraying of Zinc sulphate	Sungma	Dj	33	1973
	Arya	Dj	32	1973
Infilling	Bannockburn	--	--	1974
-do-	Ging	--	--	1974
Rejuvenation	Bannockburn	--	--	1974
-do-	Ging	--	--	1974

Appendix-B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBERS ESTATES

By

THE OTHER DEPARTMENTS

BOTANY DEPARTMENT

Sl. No.	Experiment	Loiation	Site	Year started
1.	Observation plots of biclonal progenies	North Bank, Assam	Noanipara	1966
2.	-do-	-do-	Cinnatolliah	1974
3.	-do-	South Bank, Assam	Nahorbari	1973
4.	-do-	-do-	Dolowjan	1974

ENTOMOLOGY DEPARTMENT

Sl. No.	Experiments	Location of estate	Site	Index	Year started
1.	Pink mite trial	South Bank	Socklatinga T.E.	6	May, 1974
2.	Pink and Scarlet mite trial	-do-	Napuk T.E.		August, 1974
3.	Scarlet mite	-do-	Heeleaka T.E.		September, 1974
4.	Red spider trial	-do-	Diffloo T.E.		January, 1975
5.	Scale insect trial	Darjeeling	Arya T.E.		August, 1974
6.	Red spider trial	South Bank	Dahingeapar T.E.		February, 1975
7.	Looper trial	South Bank	Gorunga T.E.		April, 1974
8.	Eelworm trial	Dooars	Newra Nadi T.E.		December, 1974
	-do-	Dooars	Lankapara T.E.		-do-
10.	Effect of longer pruning cycle on red spider infestation	South Bank	Thowra T.E.		October, 1974
11.	-do-	-do-	Duflating T.E.		August, 1974
12.	Effect of shade on scarlet mite infestation	South Bank	Socklatinga T.E.		May, 1974
13.	Effect of longer pruning cycle on red spider infestation	North Bank	Cinnatolliah T.E.		September, 1974
14.	Effect of differential manuring on red spider incidence	-do-	-do-		-do-
15.	Susceptibility of clones to Scarlet mite	-do-	-do-		-do-
16.	Cockchafer incidence in relation to mulch, unmulch & mulch with occasional spraying with Thiodan	-do-	Bargang T.E.		April, 1974
17.	-do-	-do-	Monabarie T.E.		-do-
18.	-do-	-do-	Durrung T.E.		-do-
19.	Incidence of red spider in relation to longer pruning cycle	Dooars	Huldibari T.E.		September, 1974
20.	-do-	-do-	Danguajhar T.E.		September, 1974
21.	Effect of weedicide treatment on termite incidence	Cachar	Longai Valley T.E.		September, 1974
22.	Effect of longer pruning cycle on red spider incidence	Cachar	Longai Valley T.E.		September, 1974
23.	-do-	-do-	Hattikhira T.E.		-do-
24.	Effect of mulch on cockchafer incidence	-do-	Dewan T.E.		-do-
25.	Mite incidence in relation to differential manuring	-do-	Dewan T.E. (Bundoo Div.)		-do-
26.	Termite control Trial	-do-	Boro-Jalinga T.E.		April, 1974
27.	-do-	-do-	Burnie Braes T.E.		-do-

MYCOLOGY DEPARTMENT

Sl. No.	Experiment	Location of estate	Site (T.E.)	Index No.	Year started
1.	To study the efficacy of different formulations as compared with that of a standard copper oxychloride - (Blitox) in controlling Red rust.	South Bank, Assam	Doomur-Dullong	MR 014	1974
2.	Same as above, but with Blitox at lower doses.	-do-	Dufflating	MR 015	1974
3.	Testing of a new fungicide against Thorny stem blight.	Darjeeling	Happy Valley	MC 006	1973
4.	Screening of fungicides against Black rot.	North Bank	Dhulapdung	MB 011	1974
5.	Screening of fungicides and copper at lower rates in in controlling Blister blight.	Darjeeling	Phoobsering	MF 003	1974
6.	Chemical control of Primary root diseases.	South Bank, Assam	Nahorkutia	MP 002	1973
7.	-do-	-do-	Borhat	MP 003	1974
8.	-do-	North Bank	Tarajulie	MP 004	1974
9.	-do-	Darjeeling	Balasun	MP 005	1974
10.	-do-	North Bank, Assam	Baghmari	MP 001	1965

STATISTICS DEPARTMENT

Sl. No.	Department	Project	Site (T.E.)	Index No.	Year started
1.	Statistics	Uniformity trial	Nagri Farm (Darjeeling, West Bengal)		1974

ENGINEERING RESEARCH & DEVELOPMENT DEPARTMENT

Sl. No.	Experiment	Location of estate	Site (T.E.)	Project No.	Year started
1.	Trial of Continuous Tea Roller	Upper Assam	Towkok	16.4	1974-75

Appendix-C

Banerjee, B. 1974. Population Dynamics of *Trigoniulus lumbricinus* (Gerst). *Res. Popul. Ecol.*, **16:** 132 137.

(Abs. The population of *Trigoniulus lumbricinus* in leaf litter varies between months. The annual population peak is reached during May to July after which the population declines. The seasonal population change is statistically correlated with the rainfall, but a causal relationship is difficult to establish: there is no indication that the population is regulated by any density related process either. It is speculated that a long term study of the population in different parts of its distribution range can only clarify the statistical and biological aspects of density relations.)

Banerjee, B. 1974. A demographic study of the growth rate of the red spider mite *Oligonychus coffeae* (Nietner) on two varieties of tea. *Acarology*, **16:** 428 435.

(Abs. Population parameters for the spider mite *Oligonychus coffeae* (Nietner) on the so called Assam and China varieties of tea in Kenya are given. Several demographic equations have been derived. Age-specific survivorship (l_x) and fecundity (m_x) are higher on China variety than on Assam variety of tea. The net reproductive rate (R_0), capacity for increase (r_c), and the intrinsic rate of increase (r_m) and the finite rate of increase (r) follow the similar trend. Since the physical environment for the growth of the mite population was maintained fairly uniform, the morphological and biochemical nature of the leaves may be consequential in the differential population growth of the mite).

Banerjee, B. 1975. Growth of mounds and foraging territories in *Odontotermes redemanni* (Wasmann). *Insectes Sociaux*, **22**: 207 212.

(Abs. Biological and statistical aspects of the annual cycle of growth and foraging in the mounds of *Odontotermes redemanni* (Wasmann) are described. Mound growth is rapid during November and March when both ambient temperature and rainfall are low. Growth rate of individual mounds declines as the mounds increases in height and stops at 200 cm. Foraging is nocturnal and common during March to September. The area foraged increases with the size of the mound and a positive correlation exists between them. Theoretical aspects of entrophic balance in the mounds are discussed).

Banerjee, B. 1975. Statistical methods in biology — some problems. *Prog. Sci & Tech.*

(Abs. The inherent drawbacks of the application of common statistical methods to biological processes, particularly in behaviourial studies, are discussed. Most of the biological phenomena do not follow the normal distribution which is an essential component in all parametric statistics Transformation of data to fit the normal distribution may lead to the loss of some information of biological significance. Moreover, role of probability has been overplayed in biology because some biological significance can also be attached to the rejection region of the probability curve. Time and motion which are common in most biological systems can rarely be dealt by parametric statistics.)

Banerjee, B. 1975. Long range strategies for the development of agricultural entomology in Kenya. *IDA World Bank Project Report.*

(Abs. An account is given of the infrastructure and curricula needed to develop the academic and research aspects to study the insect sciences in the context of Kenyan developmental projects.)

Banerjee, B. The development of the red crevice mite, *Brevipalpus phoenicis* (Geijskes) on coffee and tea in kenya. *J. Appl. Ent.*, **81** (in press)

Banerjee, B. Variance mean ratio and spatial distribution of animals. *Expt.*

Banerjee, B. and Basu, S.D. The minimal time required for nematode extraction by Oostenbrinks' elutriator: *Curr. Sci*, (In press)

Banerjee, B, and Sarmah, N.N. Bionomics of *Sternocera aurosignata* Thompson (Buprestidae: Coleoptera)- a pest of shade trees in tea plantations of north east India. *Ind. J. Ent.*

Banerjee, B, Das, S.C. and Mukherjee, S. New records of coccoids from shade trees and ancillary crops of tea in north east India. *Ind. J. Ent.*

Bezbaruah, H. P. (1974). Pollination in Tea (*Camellia sinensis* (L) O, Kuntze) In North-East India, J. Plant. Crops 2· (2), 6 8.

(Abs. Being heavy and sticky, the tea pollen is not wind borne. Under north-east Indian conditions, pollination is mostly carried out by small flies, but the insect populations around the flowering trees are generally inadequate to bring about large scale pollination. The observations indicate that the tea seed orchards need not be isolated in remote places, as insects with a long flying range, like bees and wasps, are not very common around the seed trees).

6. Hadfield, W. (1974). Shade in North-East Indian Tea Plantations, I: The Shade Pattern, *J. Appl. Ecol. II*, 151 178.

(Abs. The influence of interplanted shade trees on the light regime at the surface of mature tea bushes in Assam is described. The conclusion that most of the light reaching a tea bush is in the form of unmodified sunlight, either from large canopy gaps between trees or sunflecks, is reached and the spectral composition of the shade light is analysed. The methods used make it possible to characterize the intensity and constitution of nearly all light on the bush surface in both clear and uniformly overcast conditions as a basis for crop physiology studies. The rapid screening of potentially useful shade trees and use of foliage light patterns in planning mixtures and spacing of shade is dealt with and the significance of pattern to statistician and agronomists is pointed out. In a brief historical review of the use of shade trees in India and other tea-growing countries the reasons for the 'shade problem' and apparent contradictions between results of natural and artificial shade experiments are discussed.)

7. Hadfield, W. (1974). Shade in North-East Indian Tea Plantations, II: Foliar Illumination and Canopy Characteristics, *J. Appl. Ecol. II*, 179—199.

(Abs. The penetration of light into five distinct foliage patterns of tea bushes was studied and the effect of the foliage pattern on the distribution of light discussed. The two foliage types representing most of the tea bushes grown commercially in north-east India were examined in detail and their response to high fertilizer doses determined. It was shown that bushes with semi-erect leaves maintained a higher leaf-area index under normal estate conditions and responded to higher doses of fertilizers than a horizontal-leafed type. The implications of these findings to current commercial practice in north-east India are discussed and the potentiality of greatly improving existing and future yields considered.

8. Jain, N. K. & Verma, A. S. (1974). Biuret Content of Urea, I. Effect on Dwarf Indica Rice Cultivar IR 8 in Foliar Spray, *Indian J. Agric. Res.* **8**, 97 102.

(Abs. Dwarf *indica* rice (*Oryza sativa* Var. *Indica*) cultivar IR 8 exhibited no visible injury symptoms when biuret increased from 0 to 9% in urea, used for foliar spray @ 20 kg N/ha. However, almost all indices of growth and yield were adversely affected. Biuret contamination depressed grain yield primarily through a reduction in number of ear bearing tillers. A sharp reduction in grain and straw yields between 0 and 1.5% biuret levels, is suggestive of the need of more intensive investigation of the lower levels of biuret (for locating its threshold limit.

At higher levels, 6% biuret) content of urea negated the beneficial effect of 20 kg N/ha through foliar spray.

9. Jain, N.K. & Agrawal, M.C. (1974). Economics of Soil and Foliar Application of Nitrogen in Wheat Sonora—**64,** *Indian J. Agric. Res.* **8,** 43 48.

(Abs. Economics of N fertilization to wheat Sonora 64 was studied in an experiment conducted during 1966-1968 at Kanpur under irrigated conditions. Soil application of 60 kg N per hectare at the time of sowing, supplemented with 40 or 50 kg N per hectare through foliar spray gave net profit of Rs. 1987.11 and 1995.87 per hectare, respectively).

10. Rahman, F. (1975). Weed Control in Tea, *Outlook on Agriculture.* **8,** (4), 173-177.

(Abs. It is only during the last ten years that chemical methods of weed control in tea have been adopted on a large scale in some countries. Depending on circumstances, the aim may be either complete kill of all weeds, or selective elimination of the most troublesome species, or merely to keep the weeds in check at a level that does not reduce crop yield. The present article reviews current practices and problems and indicates areas in which research will be needed in future.)

Appendix-D

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1974

Table : 1 Tocklai (Mid Assam)

Latitude : 26.47'N Longitude : 94°12'E Altitude : 96.5 meter a.m.s.l.

Months 1974	Daily Temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly Evaporation	
	Mean Max.	Mean Min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth 5 cm	15 cm	30 cm	Open Pan in mm	Penman in mm
January	21.4 (22.4)	10.4 (9.3)	15.9 (15.8)	23.7	7.4	36.1 (21.6)	7 (5)	6.0 (5.8)	17.4 (19.0)	17.6 (18.2)	18.6 (19.0)	33.3	58.1
February	24.4 (24.0)	12.5 (11.9)	18.4 (18.0)	29.3	8.3	16.7 (32.3)	6 (7)	7.7 (6.2)	20.1 (20.5)	19.6 (19.8)	20.2 (20.2)	54.2	87.1
March	27.4 (27.5)	15.7 (15.4)	21.6 (21.1)	31.2	12.4	110.2 (80.3)	9 (11)	6.8 (6.7)	23.2 (24.0)	22.6 (23.0)	23.0 (23.0)	79.9	126.2
April	27.0 (28.7)	19.7 (19.0)	23.4 (23.8)	32.7	16.6	239.0 (191.8)	19 (16)	5.2 (5.9)	25.6 (26.9)	25.1 (25.8)	25.2 (25.6)	77.9	131 0
May	30.3 (29.9)	22.9 (21.8)	26.6 (25.8)	36.1	20.3	232.5 (283.1)	20 (20)	5.3 (5.0)	29.3 (28.6)	28.6 (27.7)	28.2 (27.6)	99.9	153.6
June	31.9 (31.5)	24.6 (24.1)	28.2 (27.8)	35.8	23.1	203.9 (333.0)	22 (23)	5.4 (4.4)	31.0 (30.6)	30.4 (29.6)	30.2 (29.4)	105.7	155.8
July	30.4 (32.2)	24.7 (24.6)	27.6 (28.4)	33.6	23.3	449.4 (380.2)	31 (25)	3.6 (4.7)	30.2 (31.5)	30.0 (30.6)	30.1 (30.5)	90.2	140.2
August	31.9 (32.0)	25.5 (24.5)	28.7 (28.2)	36.2	23.0	261.7 (344.1)	22 (23)	5.4 (5.0)	31.3 (31.4)	30.9 (30.6)	31.0 (30.6)	103.5	159.3
September	30.3 (31.2)	24.0 (23.9)	27.2 (27.6)	34.1	22.5	241.1 (252.5)	21 (19)	4.9 (5.0)	30.2 (31.0)	29.8 (30.2)	30.0 (30.2)	83.5	129.5
October	30.5 (29.3)	23.5 (20.9)	27.0 (25.1)	33.2	20.8	112.0 (116.8)	14 (12)	5.9 (5.6)	29.6 (28.3)	29.2 (27.9)	29.4 (28.2)	69.4	121.4
November	28.0 (26.3)	18.0 (15.1)	23.0 (20.7)	30.2	15.4	35.6 (27.3)	5 (4)	7.1 (6.1)	25.4 (23.9)	25.3 (23.6)	26.0 (24.5)	52.4	92.2
December	22.5 (23.4)	10.6 (10.6)	16.6 (17.0)	24.7	7.5	4.0 (11.1)	2 (3)	6.7 (6.0)	19.0 (19.8)	19.2 (19.6)	20.6 (20.6)	34.1	58.2

Per cent Relative Humidity

Table : 1 (a) Tocklai

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0613	94 (96)	92 (95)	90 (92)	93 (91)	90 (93)	91 (93)	92 (93)	92 (94)	94 (95)	96 (96)	95 (97)	95 (97)
1313	62 (58)	50 (55)	51 (54)	69 (63)	68 (71)	71 (75)	78 (75)	73 (75)	74 (74)	72 (72)	62 (64)	59 (60)

Note : (i) Data in brackets show previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon readings.
(iii) Penman in mm means Penman estimation of evaporation from an open water surface.

Table : 2 Silcoorie (Cachar)

Latitude : 24°50′N Longitude : 92°49′ E Altitude : 39.6 meter a.m.s.l.

Months 1974	Daily Temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly Evaporation	
	Mean Max.	Mean Min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth 5 cm	15 cm	30 cm	Open Pan in mm	Penman in mm
January	24.9 (25.9)	10.5 (10.9)	17.7 (18.4)	26.8	7.9	8.7 (20.2)	3 (2)	8.5 (8.0)	20.2 (21.4)	?	?	61.8	78.8
February	28.0 (27.5)	11.3 (12.9)	19.6 (20.2)	32.6	7.1	2.2 (54.8)	1 (4)	9.6 (8.1)	23.8 (23.2)	?	?	88.1	105.3
March	30.0 (30.8)	17.0 (16.4)	23.5 (23.6)	33.1	13.3	200.2 (99.6)	9 (7)	7.7 (8.0)	26.9 (26.9)	?	?	111.9	142.7
April	30.7 (31.9)	21.2 (20.4)	26.0 (26.2)	33.7	17.5	267.5 (250.9)	19 (14)	7.4 (7.6)	28.9 (29.4)	?	?	94.4	162.6
May	31.7 (31.9)	22.7 (22.7)	27.2 (27.3)	36.5	20.2	260.8 (388.5)	18 (19)	6.5 (6.6)	30.2 (30.6)	?	?	128.7	172.2
June	31.2 (31.5)	23.8 (24.4)	27.5 (28.0)	35.1	20.7	748.0 (596.9)	24 (25)	5.1 (4.0)	30.8 (30.6)	?	?	114.0	183.1
July	30.2 (32.2)	24.4 (25.0)	27.3 (28.6)	34.1	23.3	630.3 (519.6)	31 (27)	2.6 (1.5)	30.2 (31.4)	?	?	71.8	126.5
August	32.9 (32.2)	24.9 (24.9)	28.9 (28.6)	36.8	21.6	370.8 (113.8)	24 (25)	4.6 (4.8)	31.6 (31.4)	?	?	69.7	132.7
September	31.7 (32.4)	23.8 (24.5)	27.8 (28.4)	35.6	21.8	355.1 (338.9)	18 (18)	5.5 (5.7)	30.6 (31.3)	?	?	91.1	139.4
October	32.3 (31.3)	23.6 (22.1)	28.0 (26.8)	36.1	20.9	210.8 (215.8)	11 (11)	6.7 (6.6)	30.6 (29.6)	?	?	75.3	138.3
November	30.6 (29.2)	20.0 (17.1)	25.3 (23.2)	33.1	17.1	46.7 (29.1)	7 (3)	7.6 (7.8)	28.8 (25.9)	?	?	72.2	109.5
December	25.8 (26.9)	11.9 (12.5)	18.8 (19.7)	27.5	9.9	(00.0) (11.3)	0 (1)	7.8 (8.0)	21.3 (22.6)	?	?	45.5	75.9

Per cent Relative Humidity

Table : 2(a) Silcoorie (Cachar)

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0619	98 (98)	99 (97)	98 (94)	93 (91)	93 (91)	95 (95)	97 (95)	95 (96)	97 95	97 (96)	98 (97)	99 (98)
1319	50 (46)	38 (43)	56 ((42)	65 (56)	69 (67)	76 (76)	84 (75)	74 (74)	75 (71)	71 (67)	60 (56)	52 (49)

Note : (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings.
(iii) Penman in mm means Penman estimation of evaporation from an open water surface.
(iv) ? indicates data not available.

Table : 3 Nagrakata (Dooars)

Latitude : 26°34'N Longitude : 88°55'E Altitude : 228.6 meter a.m.s.l.

Months 1974	Daily Temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly Evaporation	
	Mean Max.	Mean Min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth 5 cm	15 cm	30 cm	Open Pan in mm	Penman in mm
January	22.8 (23.6)	10.2 (10.5)	16.5 (17.0)	25.5	6.5	42.1 (11.2)	4 (2)	5.3 (7.7)	18.2 (18.2)	18.6 (18.4)	19.4 (19.6)	66 0	62.7
February	25.4 (25.5)	11.5 (12.9)	18.4 (19.2)	29.8	6.7	0.0 (21.1)	0 (3)	8.0 (7.5)	20.4 (20.2)	20.5 (20.0)	20.8 (20.7)	88.4	93.0
March	28.7 (29.4)	16.5 (16.4)	22.6 (22.9)	33.0	13.7	40.9 (41.7)	5 (5)	6.4 (7.6)	24.8 (24.0)	24.8 (23.5)	24.6 (23.8)	151.9	135.8
April	29.5 (31.1)	20.2 (20.0)	24.8 (25.6)	32.5	15.0	187.0 (142.8)	15 (11)	6.2 (7.2)	25.8 (27.0)	25.5 (26.4)	25.4 (26.6)	113.6	149.8
May	30.2 (30.8)	21.5 (21.7)	25.8 (26.2)	34.9	18.5	580.4 (342.4	20 (20)	6.0 (6.6)	26.4 (28.6)	27.1 (27.6)	27.0 (28.0)	?	164.8
June	31.0 (30.3)	23.2 (23.3)	27.1 (26.8)	34.6	19.0	460.3 (902.3)	23 (26)	3.9 (3.8)	28.6 (28.5)	28.4 (28.0)	28.6 (28.4)	?	138.8
July	29.3 (30.4)	23.6 (23.9)	26.4 (27.2)	32.7	22.1	1398.0 (1055.8)	27 (27)	2.0 (3.5)	26.6 (29.0)	27.8 (28.4)	27.8 (28.8)	?	117.6
August	30.7 (30.6)	24.0 (23.7)	27.4 (27.2)	35.5	22.5	891.9 (773.7)	22 (27)	3.4 (4.1)	27.8 (29.2)	28.6 (28.8)	28.0 (29.0)	?	131.8
September	29.7 (30.6)	22.5 (22.9)	26.1 (26.8)	34.2	19.2	576.6 (548.3)	23 (21)	4.5 (5.1)	27.2 (28.8)	27.6 (28.8)	27.4 (28.8)	111.2	122.0
October	30.2 (29.8)	21.5 (19.4)	25.8 (24.6)	33.0	16.0	462.3 (210.7)	13 (10)	6.6 (7.8)	27.0 (26.8)	27.6 (27.2)	27.4 (27.2)	101.2	126.4
November	29.4 (27.3)	14.8 (14.6)	22.1 (21.0)	31 0	11.5	0.0 (13 2)	0 (3)	9.7 (8.6)	23.2 (22.6)	23.6 (22.8)	24.3 (24.0)	93.0	103.9
December	23.8 (24.9)	10.9 (11.5)	17.4 (18.2)	25.6	8.6	0.0 (4.0)	0 (1)	7.7 (8.4)	18.6 (19.5)	19.2 (19.8)	20.2 (21.1)	70.0	68.1

Per cent Relative Humidity

Table : 3 (a) Nagrakata (Dooars)

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0634	92 (85)	85 (81)	72 (74)	86 (76)	89 (87)	93 (95)	97 (96)	95 (95)	94 (95)	94 (88)	79 (85)	86 (85)
1334	53 (52)	42 (49)	42 (45)	66 (53)	71 (69)	77 (82)	85 (83)	81 (82)	78 (78)	71 (66)	47 (57)	50 (53)

Note : (i) Data in brackets show previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon readings?
(iii) Penman in mm means Penman estimation of evaporation from an open water surface.

Table 4. Nagri-Farm (Darjeeling)

Latitude : 26°55'N Longitude : 88°12'E Altitude : 1158.2 meters a.m.s.l.

Months 1974	Daily Temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly Evaporation	
	Mean Max.	Mean Min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth 5 cm	15 cm	30 cm	Open Pan in mm	Penman in mm
January	14.7 (15.2)	7.4 (7.8)	11.0 (11.5)	18.9	4.1	24.1 (19.0)	5 (3)	5.3 (6.2)	12.9 (13.3)	11.3 (12.4)	14.2 (14.0)	35.7	51.2
February	17.1 (16.7)	9.2 (9.5)	13.2 (13.1)	22.7	5.0	3.6 (18.3)	1 (3)	6.5 (5.9)	15.2 (14.7)	12.1 (13.5)	14.6 (14.5)	53.3	76.6
March	22.2 (21.2)	13.5 (13.0)	17.8 (17.1)	24.6	10.2	26.2 (54.2)	5 (5)	6.3 (6.8)	20.0 (18.9)	17.0 (17.1)	18.8 (17.6)	102.2	119.4
April	22.7 (23.6)	15.3 (15.8)	19.0 (19.7)	27.0	11.4	169.2 (96.8)	14 (10)	5.3 (5.7)	21.2 (21.8)	18.8 (20.0)	20.1 (20.3)	63.0	123.0
May	23.8 (23.9)	17.2 (17.2)	20.5 (20.6)	28.8	14.1	186.8 (198.1)	21 (19)	4.5 (5.2)	23.1 (23.6)	20.7 (21.8)	21.8 (22.0)	71.3	126.4
June	24.0 (24.1)	18.6 (18.8)	21.3 (21.4)	28.6	15.9	278.7 (434.3)	23 (25)	3.3 (2.9)	24.6 (24.5)	22.1 (23.2)	22.4 (23.2)	57.0	114.9
July	24.2 (24.3)	18.7 (19.4)	21.4 (21.8)	26.6	17.7	986.5 (651.0)	28 (27)	1.6 (2.5)	23.8 (24.8)	21.8 (23.5)	23.2 (23.8)	52.7	106.4
August	24.9 (24.7)	19.2 (19.1)	22.0 (21.9)	29.0	17.5	553.9 (471.3)	23 (26)	2.5 (3.3)	26.5 (25.2)	22.4 (23.8)	23.7 (24.2)	61.0	108.1
September	24.3 (24.4)	17.8 (18.2)	21.0 (21.3)	28.6	16.5	306.1 (316.9)	22 (20)	3.4 (4.0)	23.9 (24.4)	21.6 (23.2)	23.2 (23.8)	55.9	98.1
October	23.8 (23.2)	17.1 (15.6)	20.4 (19.4)	26.4	13.8	92.2 (147.1)	16 (8)	(5.1) (6.7)	22.0 (22.1)	20.6 (20.9)	22.4 (21.8)	52.7	97.1
November	23.6 (20.3)	13.5 (11.8)	18.6 (16.0)	25.5	10.4	3.6 (12.9)	1 (2)	8.9 (7.3)	19.0 (18.1)	16.4 (17.2)	19.1 (18.8)	82.3	92.5
December	17.0 (17.7)	8.1 (9.3)	12.6 (13.5)	23.0	6.0	23.4 (2.3)	4 (1)	5.4 (7.0)	12.8 (14.8)	11.0 (14.0)	14.3 (15.7)	41.1	53.4

Per cent Relative Humidity

Table 4(a). Nagri-Farm (Darjeeling)

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0637	77 (71)	68 (69)	66 (63)	75 (69)	96 (80)	90 (92)	96 (94)	92 (93)	90 (89)	86 (76)	57 (68)	66 (69)
1337	80 (72)	59 (65)	63 (59)	78 (66)	92 (82)	88 (89)	92 (89)	83 (87)	85 (86)	82 (79)	56 (71)	70 (70)

Note : (i) Data in brackets shows previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon readings.
(iii) Penman's in mm means Penman estimation of evaporation from an open water surface.

Table 5. North Bank of Brahmaputra, Assam Thakurbari

Latitude : 26°35'N Longitude : 92°42'35"E Altitude : 92.45 Meters a.m.s.l.

Months 1974	Daily Temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly Evaporation	
	Mean Max.	Mean Min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth 5 cm	15 cm	30 cm	Open Pan in mm	Penman in mm
January	23.4	9.0	16.2	25.1	5.2	36.2	6	7.0	?	?	?	50.5	63.6
February	26.2	11.4	18.8	30.2	6.4	0.4	2	7.2	?	?	?	75.3	88.8
March	29.4	15.1	22.2	33.2	11.4	45.3	5	6.9	?	?	?	121.9	132.5
April	28.9	19.5	24.2	34.9	16.3	119.8	20	5.4	?	?	?	109.2	134.6
May	30.4	21.9	26.2	36.3	19.0	226.1	16	4.9	?	?	?	108.5	151.2
June	31.8	24.0	27.9	35.6	22.6	564.8	26	3.8	?	?	?	129.0	142.6
July	31.0	24.4	27.7	34.5	23.2	662.7	28	3.1	?	?	?	120.9	132.7
August	32.3	24.7	28.5	36.3	23.0	320.1	22	4.9	?	?	?	117.8	153.7
September	30.7	23.2	27.0	35.1	22.0	527.1	22	4.8	?	?	?	89.1	125.9
October	30.8	21.9	26.4	34.5	19.0	196.5	10	6.0	?	?	?	74.5	121.5
November	29.0	15.4	22.2	31.0	12.0	0.0	0	8.8	?	?	?	63.4	96.1
December	24.0	9.5	16.8	26.3	6.6	17.2	4	8.1	?	?	?	38.6	65.5

Per cent Relative Humidity

Table 5(a). (North Bank of Brahmaputra, Assam) Thakurbari

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0619	96	92	86	93	92	93	95	92	92	93	92	91
1319	61	52	52	72	73	76	81	77	78	74	57	53

Note : (i) Data in brackets show previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon readings.
(iii) Penman in mm mean Penman estimation of evaporation from an open water surface.
(iv) ? indicates data not available.